

ED12 Considerations for Implementing PlantPAx Batch and Sequence Manager

by

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THINKING **PROCESS**

Rockwell Automation
Process Solutions User Group (PSUG)
November 14-15, 2011
Chicago, IL – McCormick Place West

Agenda

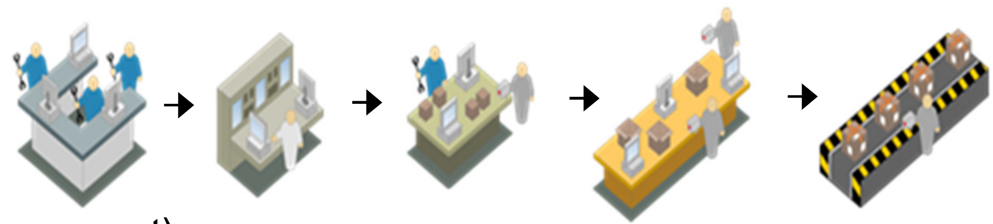
- Batch and Sequencing processes
- Batch and sequencing S88 design basis
- Batch and Sequencing Solutions
- Batch and Sequencing scalability
- Scalable solution example
- Selection Considerations
- Summary

Agenda

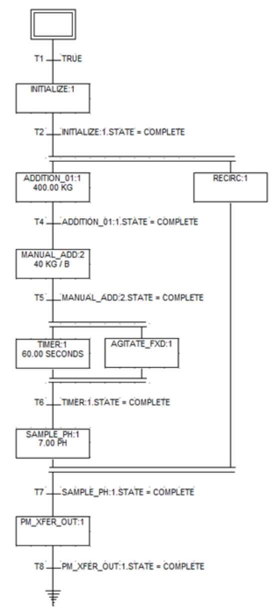
- Batch and Sequencing processes
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Terms used to describe sequencing activities

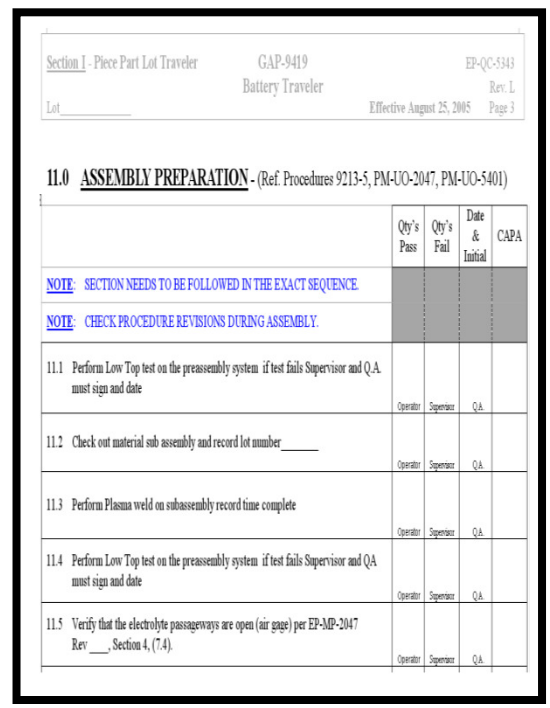
- **Workflow-**
  - Common term used in describing
  - MES system or
  - MOM (Manufacturing Operations Management)



- **Procedure -** well defined in the ISA-88
  - Batch procedure
  - Unit procedure
  - Operation



- **Work instructions**



Section 1 - Piece Part Lot Traveler | GAP-9419 Battery Traveler | EP-QC-5343 Rev. L

Lot ________ | Effective August 25, 2005 | Page 3

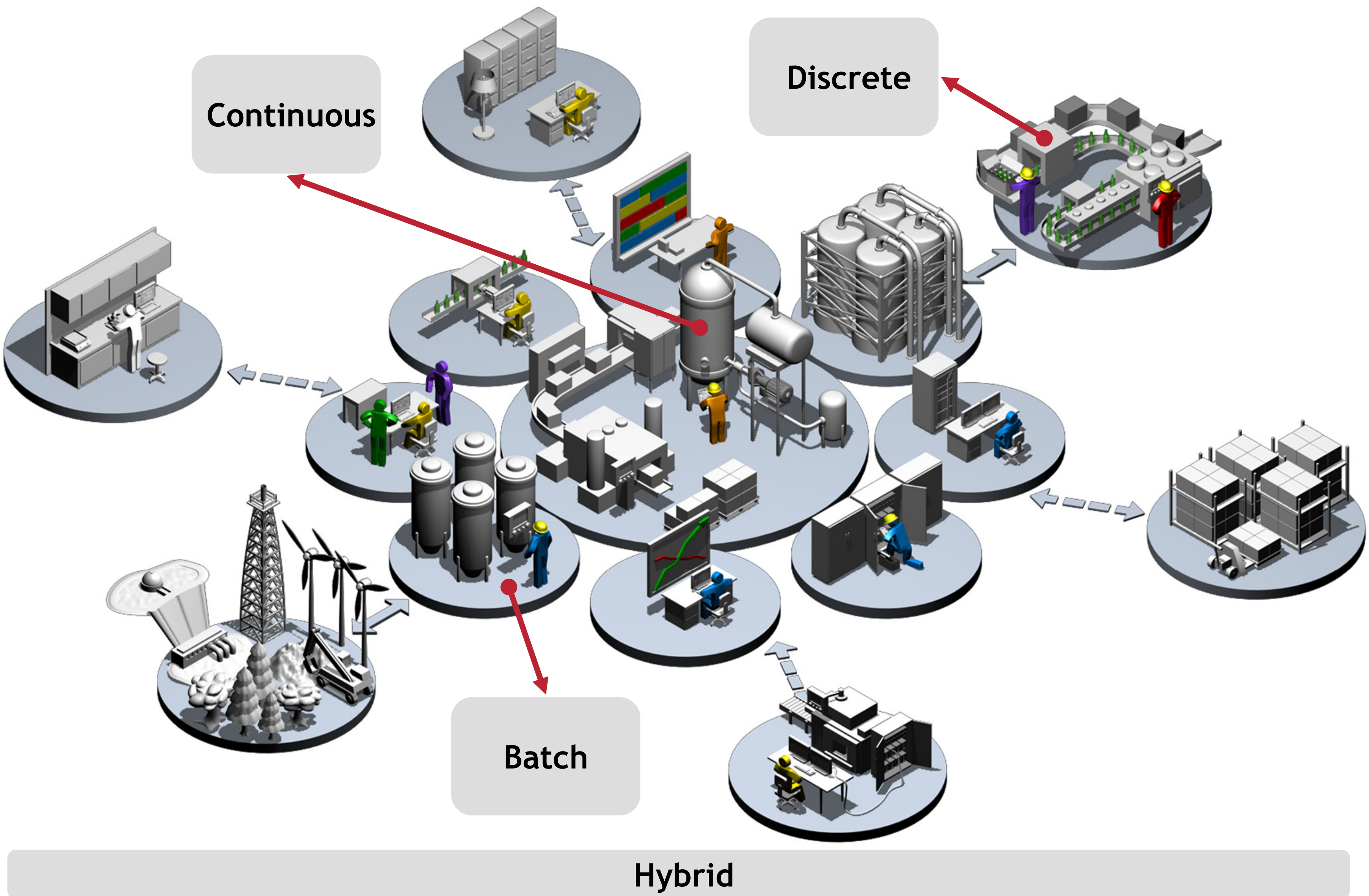
11.0 ASSEMBLY PREPARATION - (Ref. Procedures 9213-5, PM-UO-2047, PM-UO-5401)

	Qty's Pass	Qty's Fail	Date & Initial	CAPA
NOTE: SECTION NEEDS TO BE FOLLOWED IN THE EXACT SEQUENCE.				
NOTE: CHECK PROCEDURE REVISIONS DURING ASSEMBLY.				
11.1 Perform Low Top test on the preassembly system if test fails Supervisor and Q.A. must sign and date	Operator	Supervisor	Q.A.	
11.2 Check out material sub assembly and record lot number______	Operator	Supervisor	Q.A.	
11.3 Perform Plasma weld on subassembly record time complete	Operator	Supervisor	Q.A.	
11.4 Perform Low Top test on the preassembly system if test fails Supervisor and QA must sign and date	Operator	Supervisor	Q.A.	
11.5 Verify that the electrolyte passageways are open (air gage) per EP-MP-2047 Rev___, Section 4, (7.4).	Operator	Supervisor	Q.A.	

- **Routing**

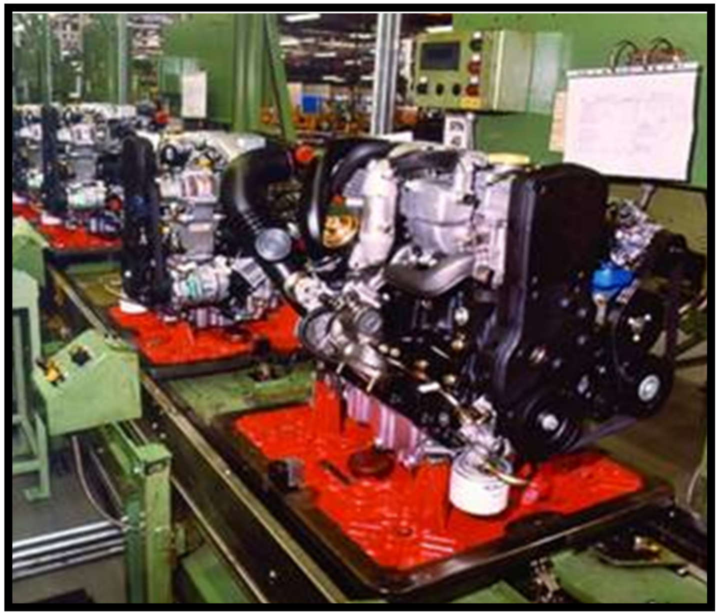


Types of processes

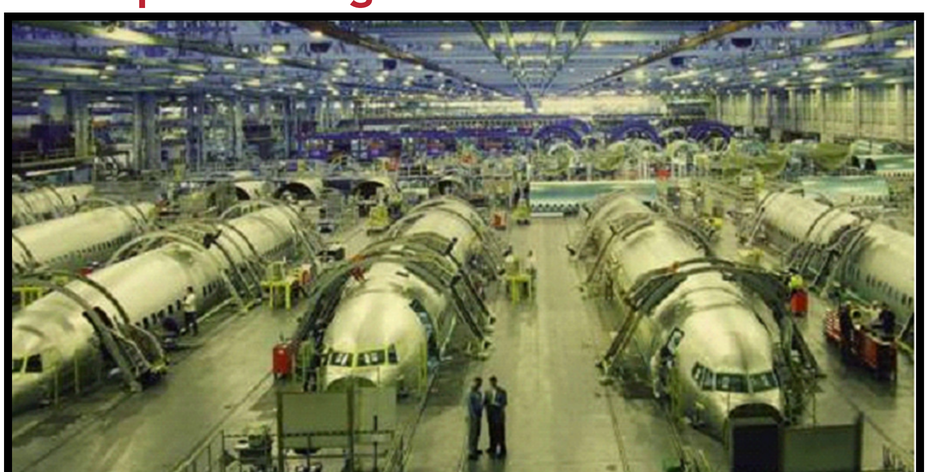


Discrete manufacturing

Assembly sequencing

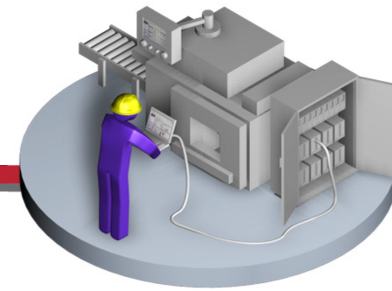


Parts processing



- Assembly
  - Engines
  - Power Train
- Semiconductor
  - Cleaning
  - Etching
  - Deposition
- Assembly
  - Electronics
  - Appliances
- Coating
  - Galvanizing
  - Plating
  - Chemical milling…

Continuous processing



Petrochemical . . .



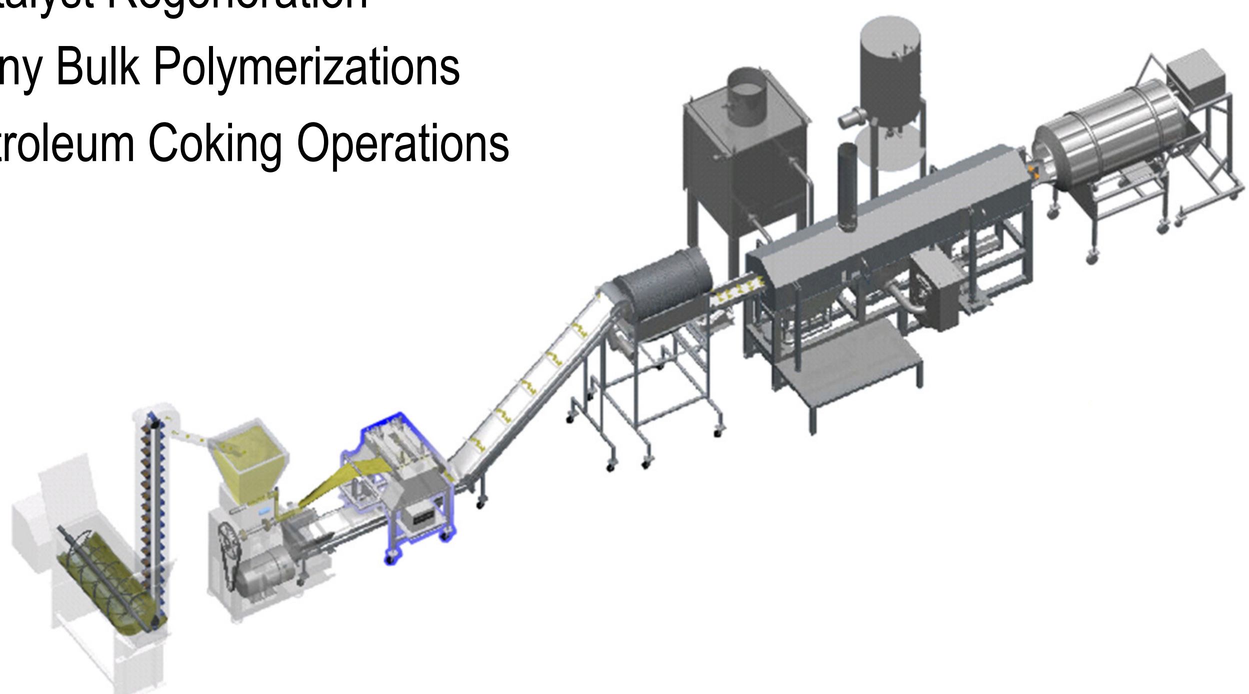
For all continuous processes….

Sequencing in startup, shutdown, product grade change over, and abnormal handling conditions

- Pressure Swing Absorption
- Catalyst Regeneration
- Many Bulk Polymerizations
- Petroleum Coking Operations

Food & Beverage

- Food extruders
- Continuous ovens
- Continuous coaters
- Distillation towers



Batch processing



Pharmaceutical & Chemical

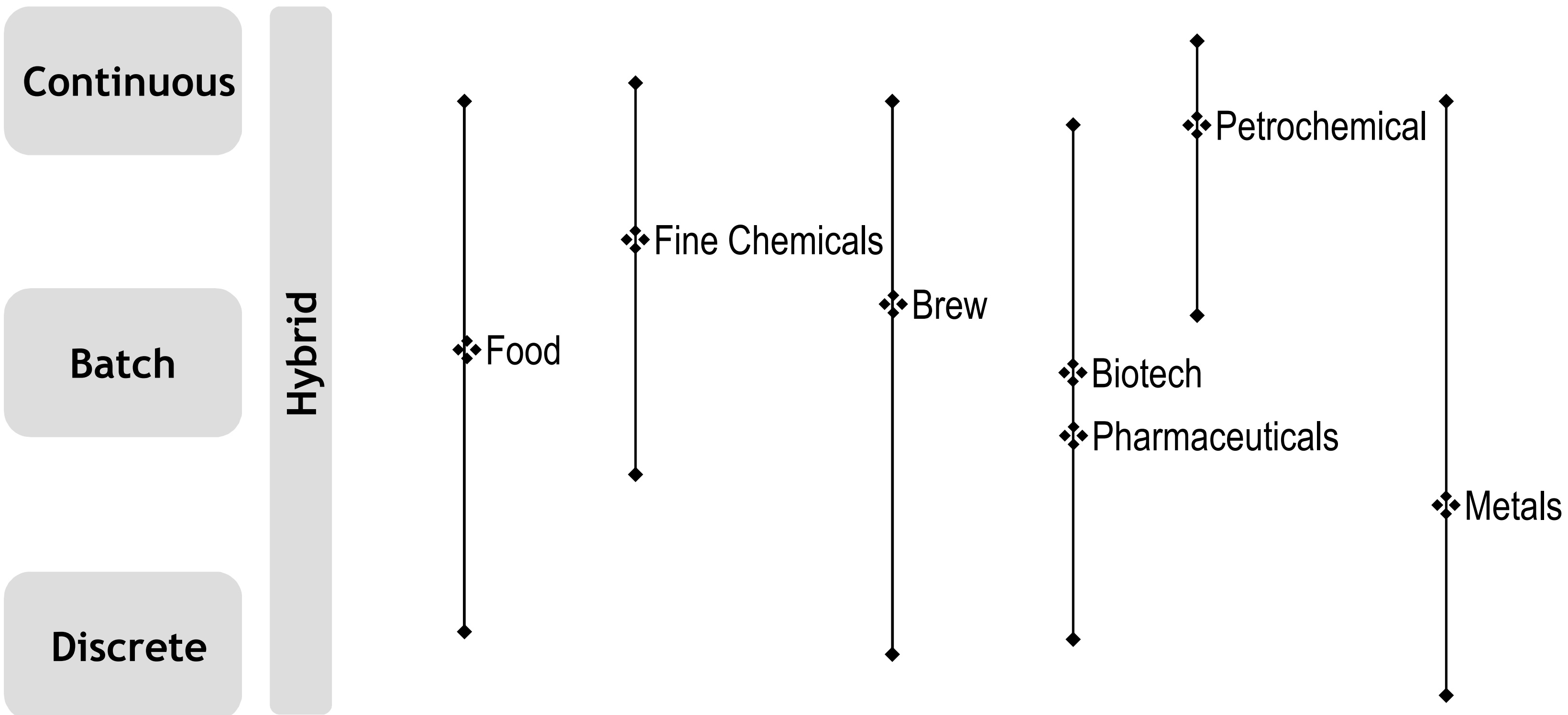


Food and Beverage



- Making discrete quantities of products
- Typically, the most comprehensive sequencing
  - May be up to 4 different layers in manufacturing process alone
  - Often very complex sequencing paths with many ‘and’ & ‘or’ divergences
  - Often requires constant changes for agile manufacturing requirements
  - The procedure drives production. Completing the procedure completes the product
- ISA-88 standard gives comprehensive guidance in designing a modular, flexible system

Industries and types of processes



Requirements Complexity factors (some)

- Cost
- Single-unit execution or Multi-unit coordination
- Large system
- Procedures size & sophistication
- Equipment allocation and arbitration
- Operator Simple prompting or Electronic Work Instructions
- Data collecting, reporting, analysis
- Redundancy
- Safety
- Security & regulatory compliance
- Material Management
- Information enabled
- ERP/MES connectivity

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Automation for the Process Industry

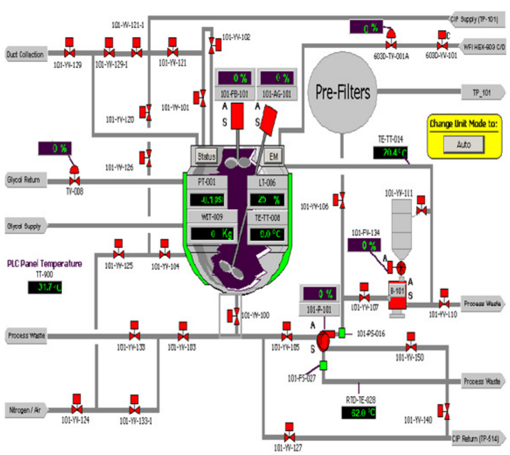


Engineering Aspects (Modularity)

FUNDAMENTAL ISA-S88 CONCEPT

Equipment

What is the equipment capable of ?



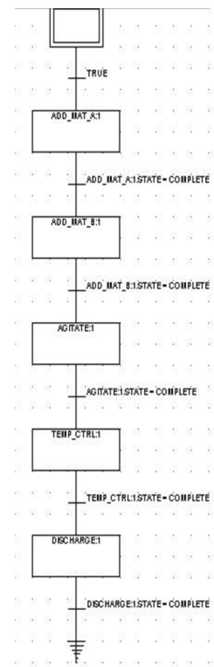
Engineer

“ SEPARATE ”



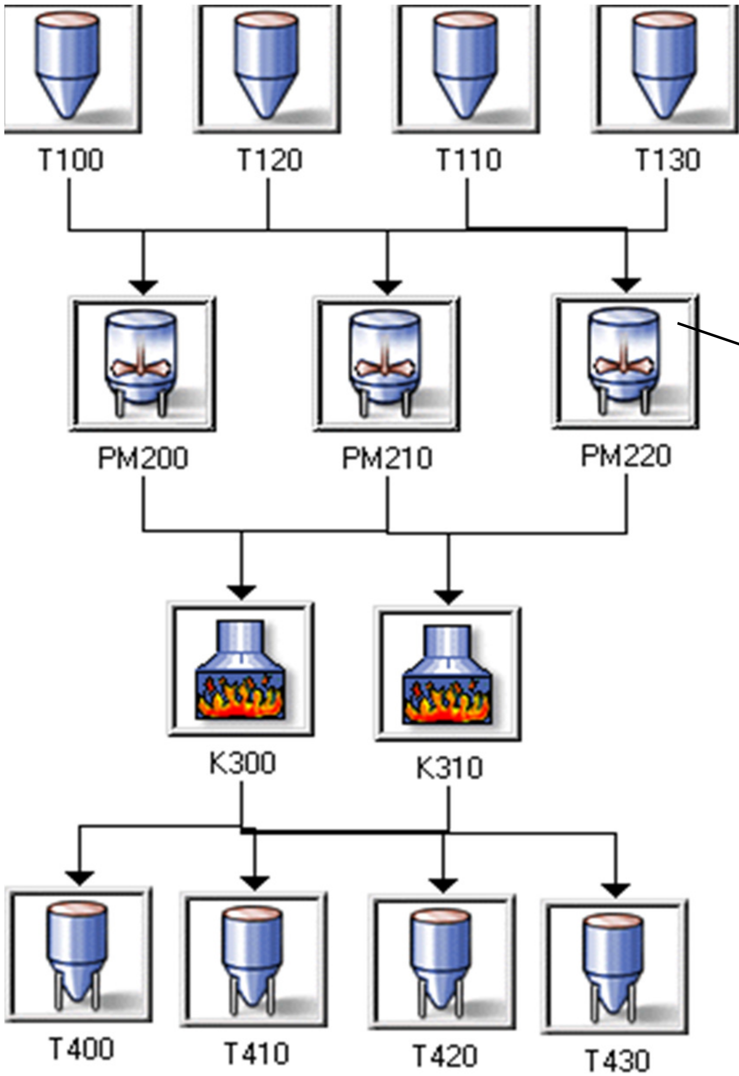
Procedure

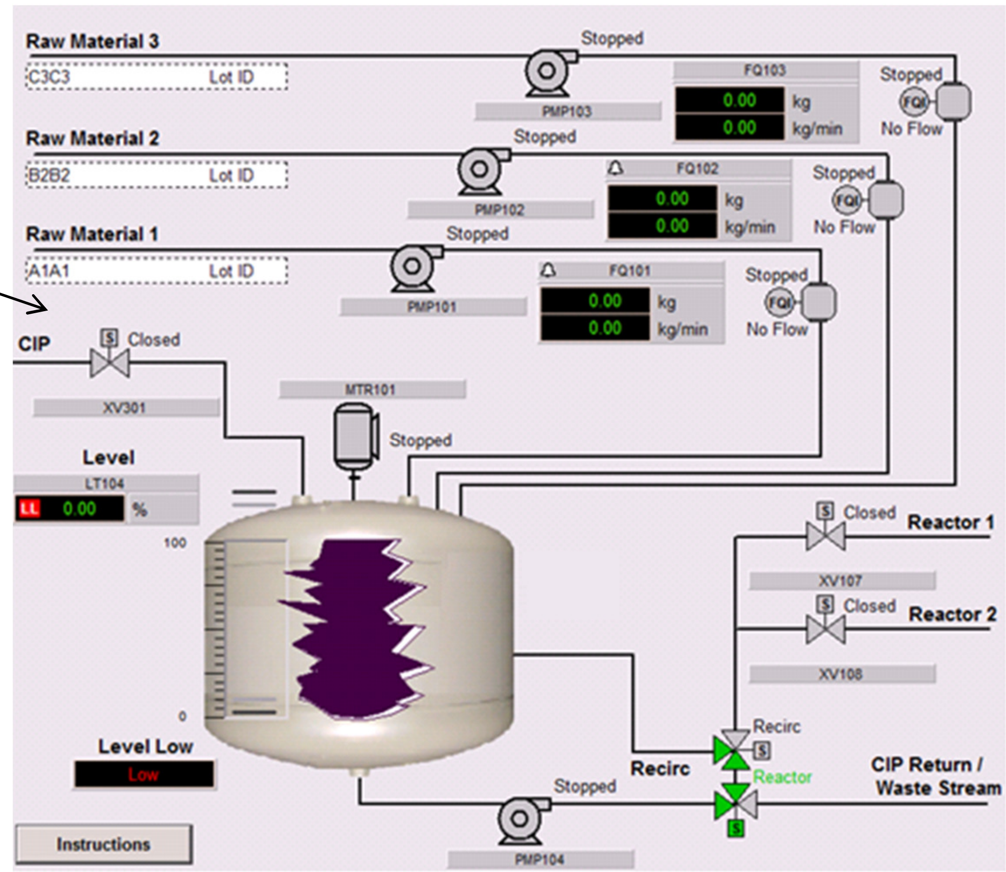
What to do with the equipment ?



Formulator

Engineering Aspects (What is the equipment capable of ?)

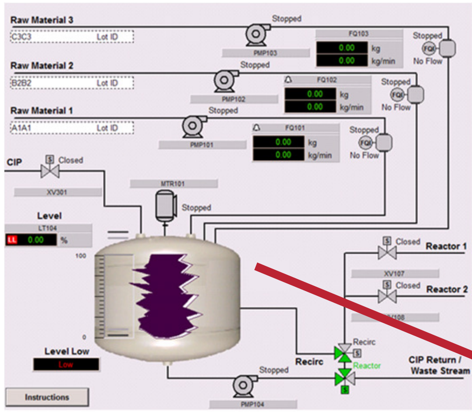




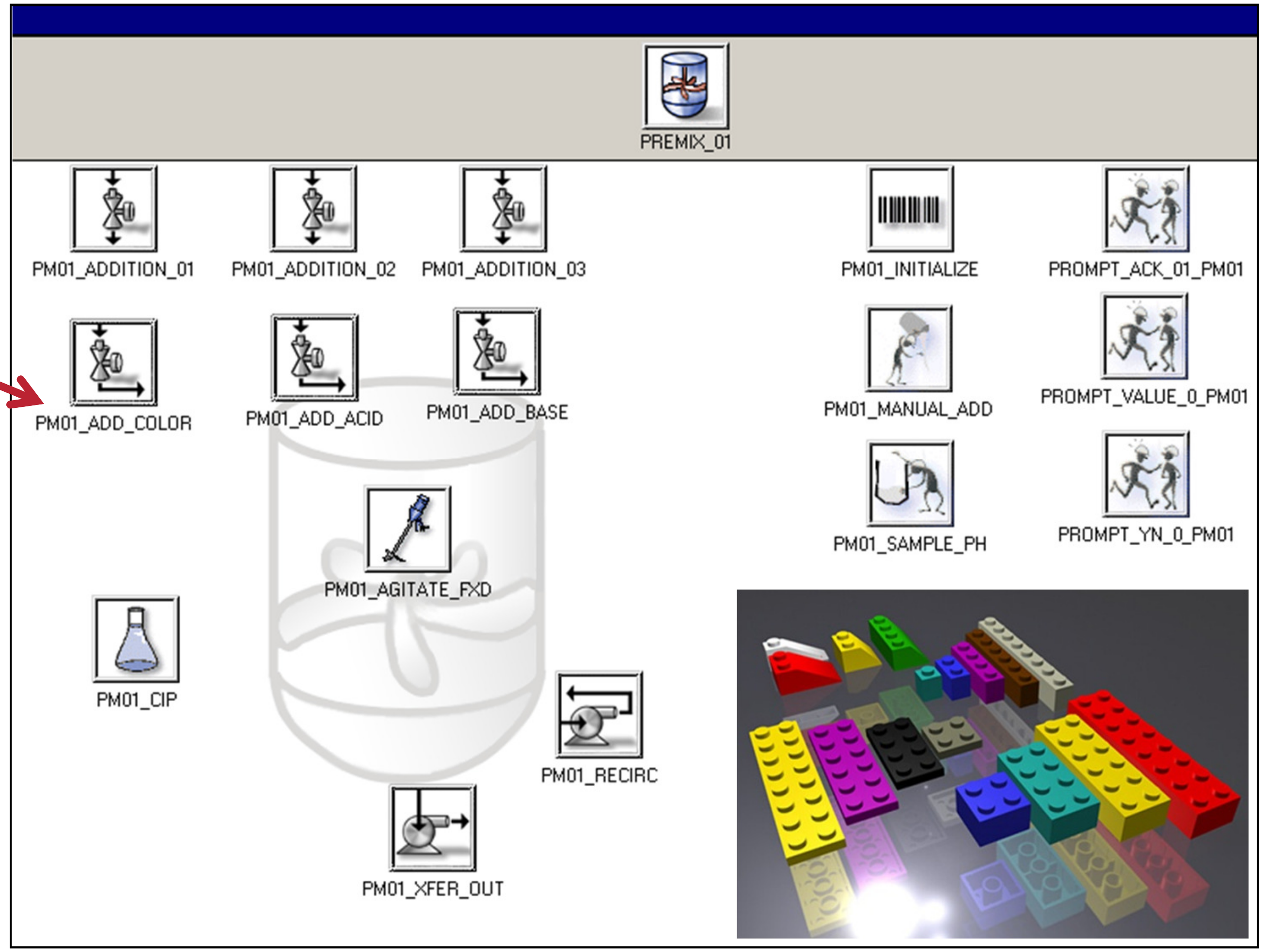
Process **Unit**

Engineering Aspects (Modularity) Programming

Unit



Phases

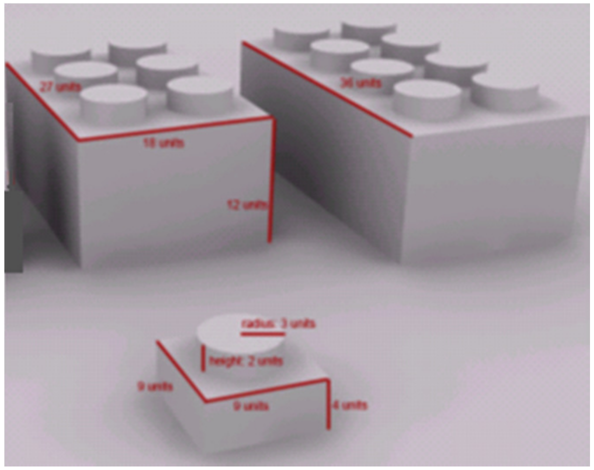


What is the equipment capable of ?

Phases are the building blocks of a modular solution

Phase Manager

Phase Manager



+

Logic definition



=

Equipment Phase

- Controller firmware
- Phase infrastructure
- Phase tags
- State transition logic
- Phase logic interface

- Parameters
- Report Values
- Execution logic

- Reusable
- Modular code

Rockwell's response to market demand for modular solutions

- Encapsulated basic equipment functionality (Agitate, Add, Heat, Cool, Transfer, etc.)
- Product or procedure independent
- Sequencing engine independent

Formulator Aspects

What can I do with this equipment (phases)?

What do I want to make today?


PM01_ADDITION_01

PM01_INITIALIZE


PM01_MANUAL_ADD




PM01_TIMER1


PM01_XFER_OUT


PM01_AGITATE_FXD

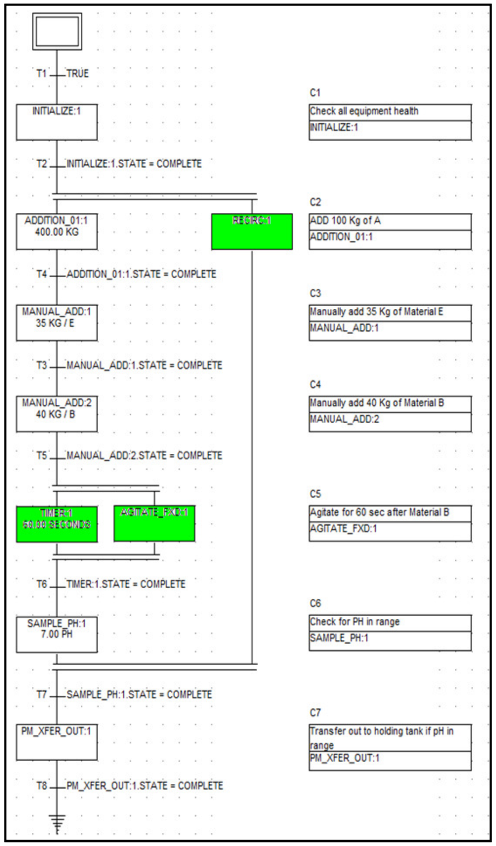
Formulator

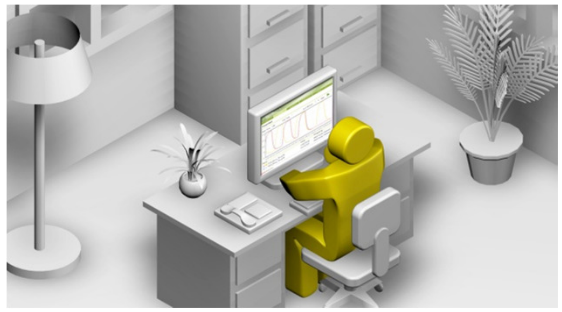

PM01_SAMPLE_PH


PM01_RECIRC

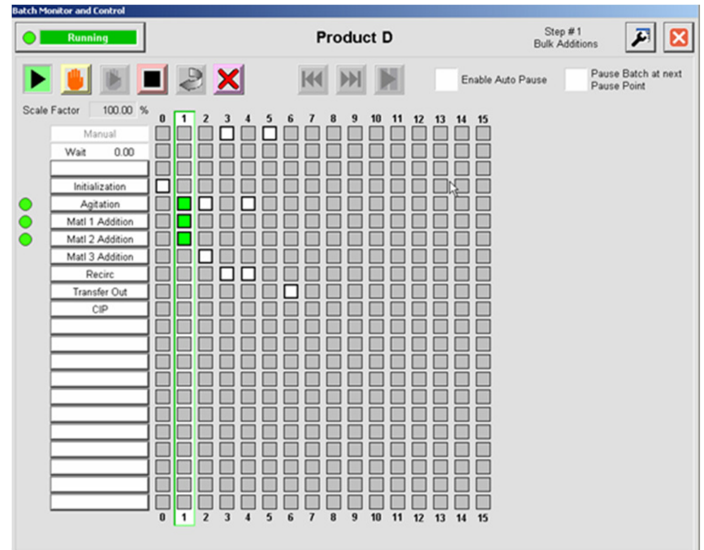
Formulator Aspects (Modularity) Configuration

What to do with the equipment?





Research & Development

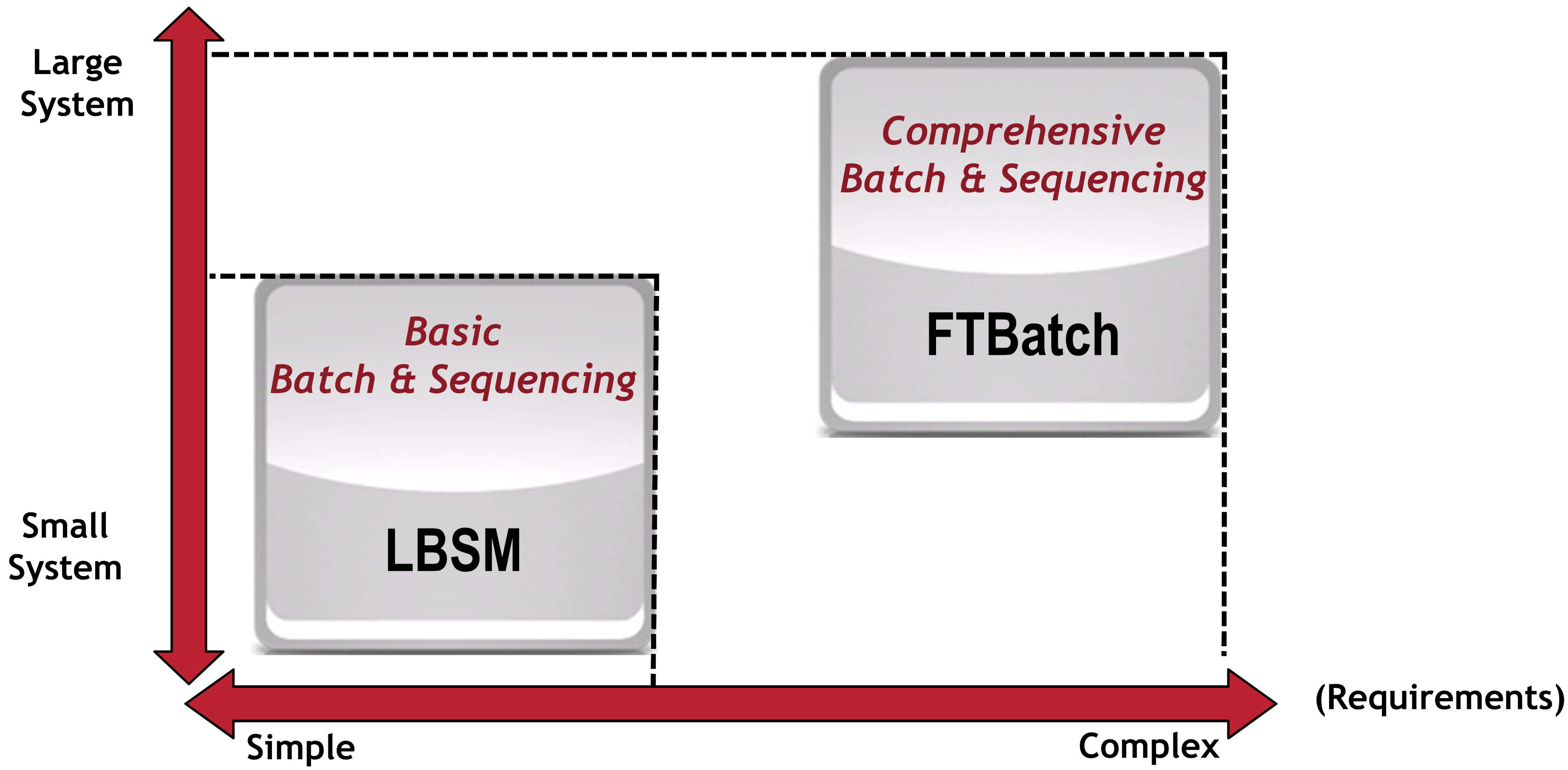


- ❑Product recipes
- ❑Experimental Recipes
- ❑Cleaning (CIP) recipes
- ❑Material Qualification recipes
- ❑Equipment setup procedures
- ❑Dispensing procedures
- ❑Startup sequences
- ❑Shut down sequences
- ❑Etc.

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Scalable Batch and Sequencing



Rockwell's response to market demand for scalable solutions

- Scalable to meet a wide range of batch and sequencing requirements

Controller-Based Batch and Sequencing

Logix Batch & Sequence Manager (LBSM)

Recipe Management and Procedural Control

ControlLogix

CompactLogix





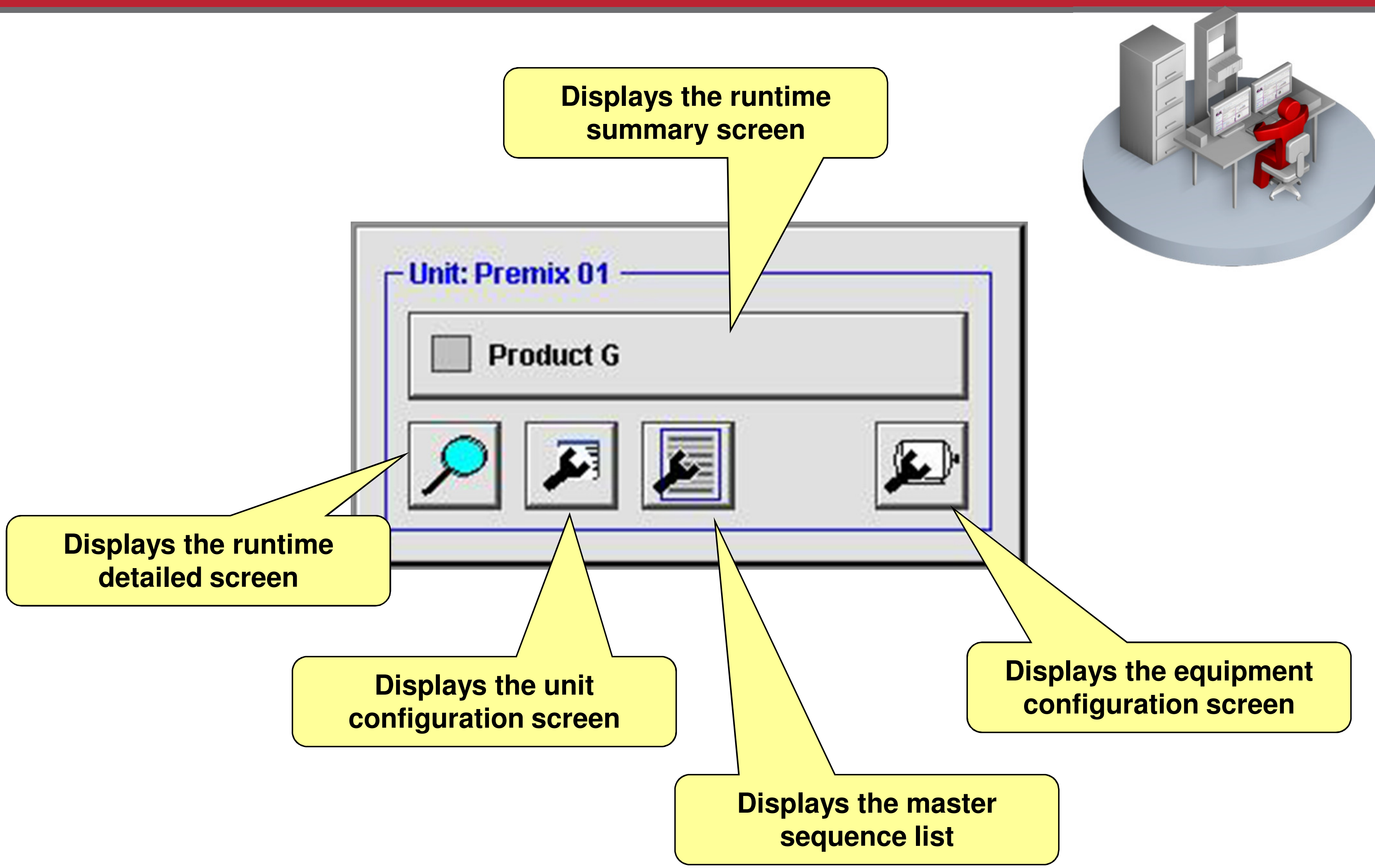
FTView SE

FTViewME

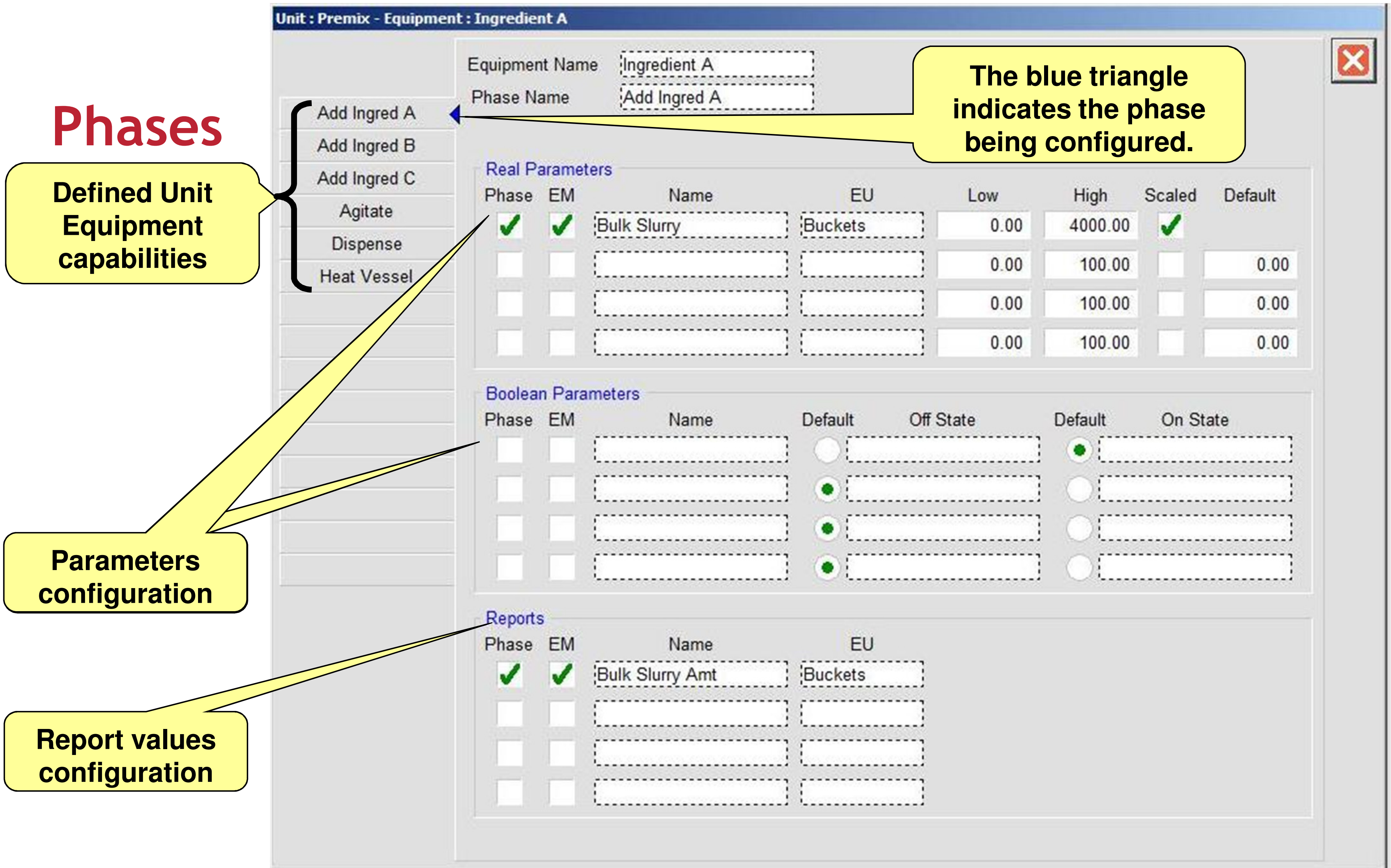
What it Offers

- Simplify your system with core system functions (controller & HMI) for batch & sequence control
- Enable flexible recipe management with configurable equipment model
- Adopt industry standard procedural control following ISA-88 state model (running, holding, stopping, etc)
- Reduce engineering with pre-built application solution

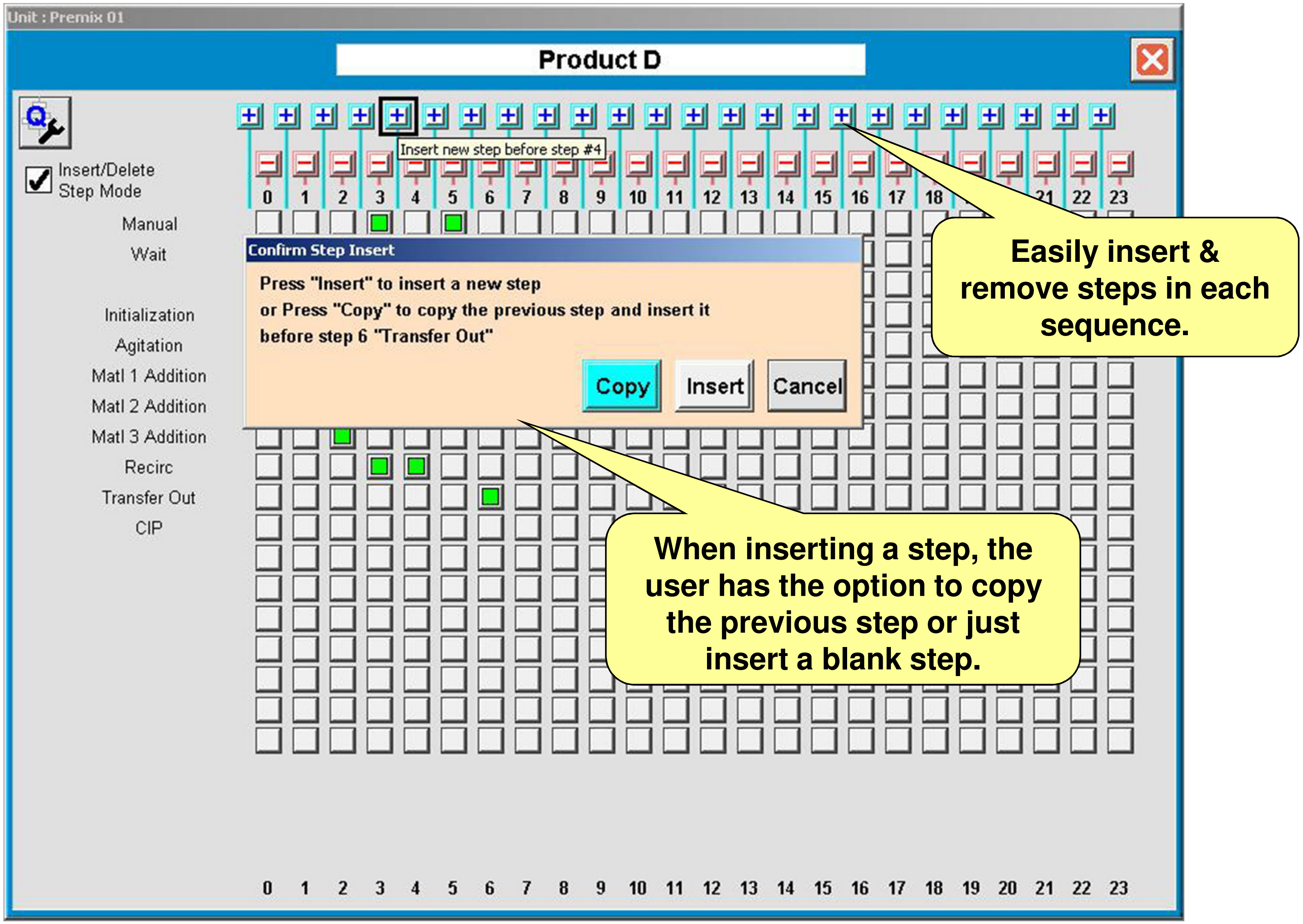
Runtime & Engineering Configuration



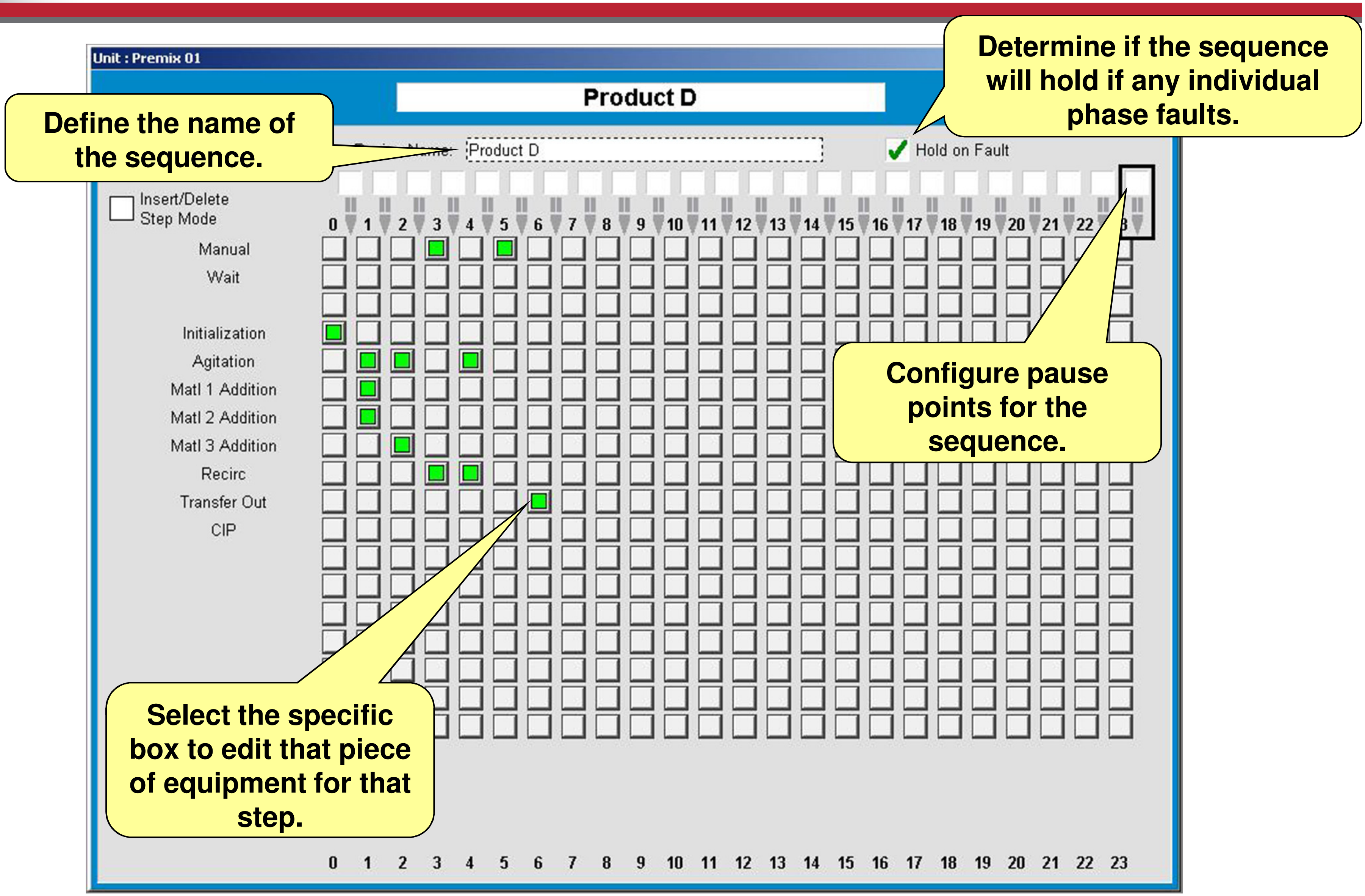
Configure the Unit Equipment Model



Insert or Remove Steps



Sequence Configuration

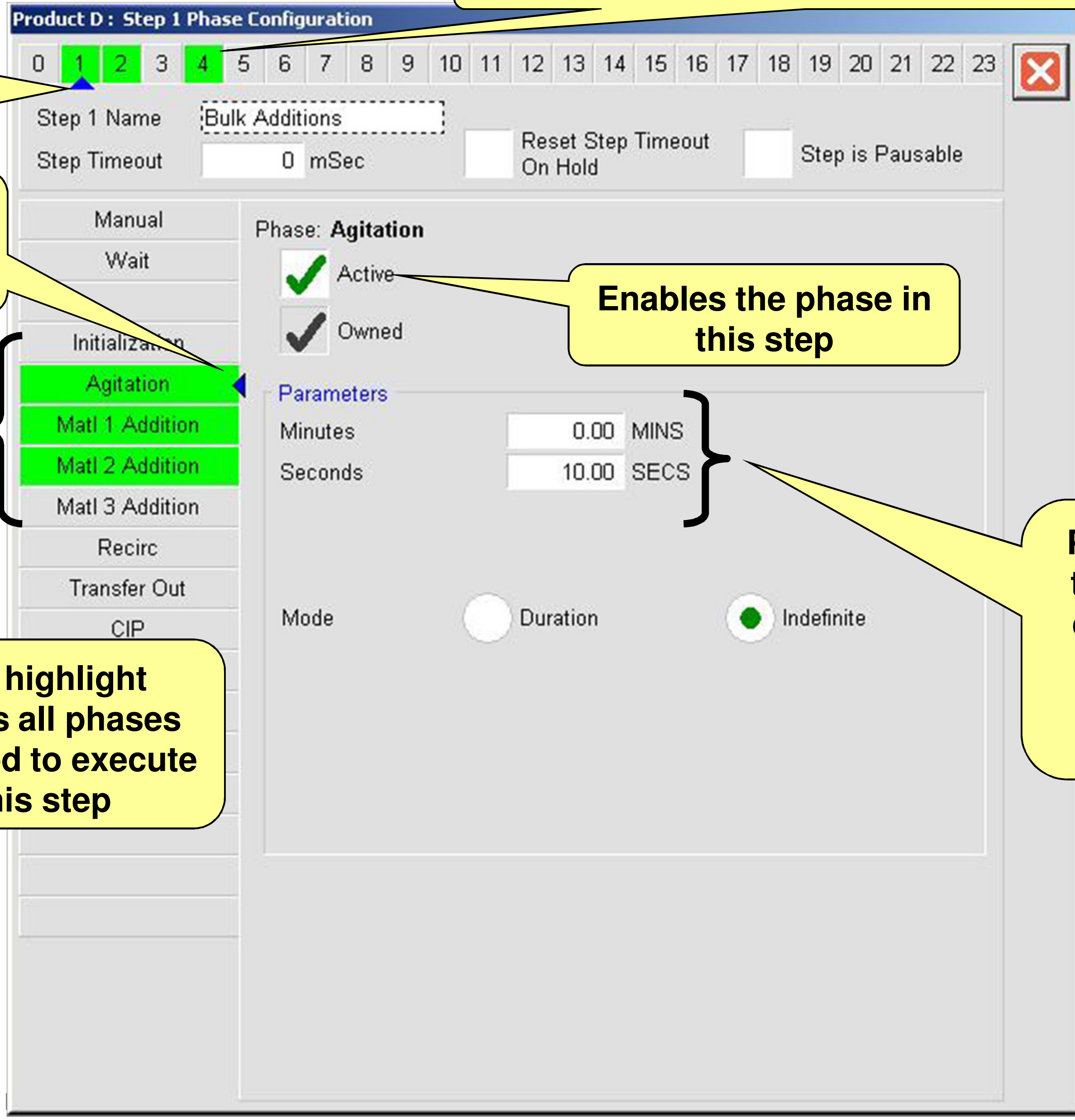


Configure the Sequence Details

Indicates steps that use the selected phase

Step selected for configuration

Phase selected for configuration in this step

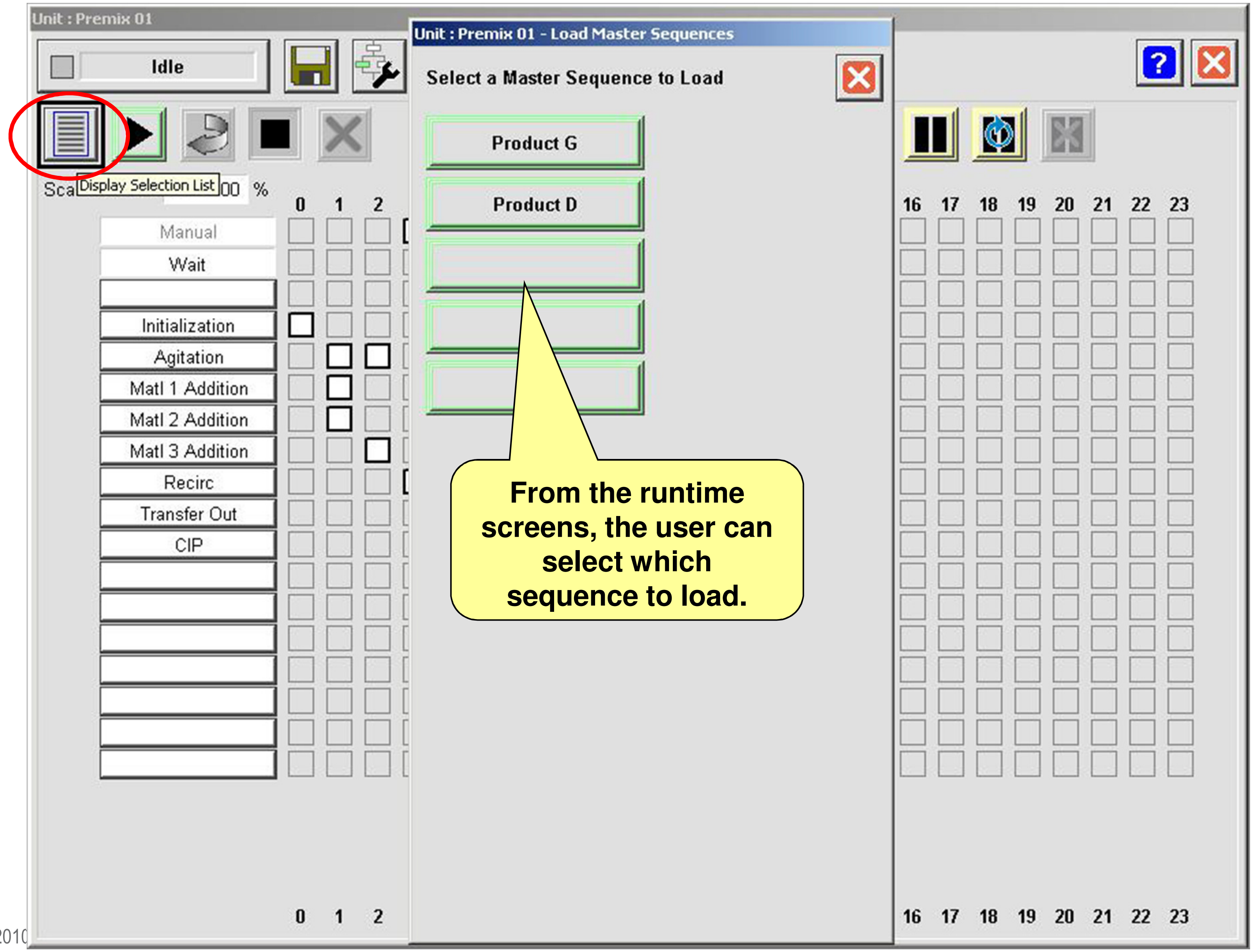


Enables the phase in this step

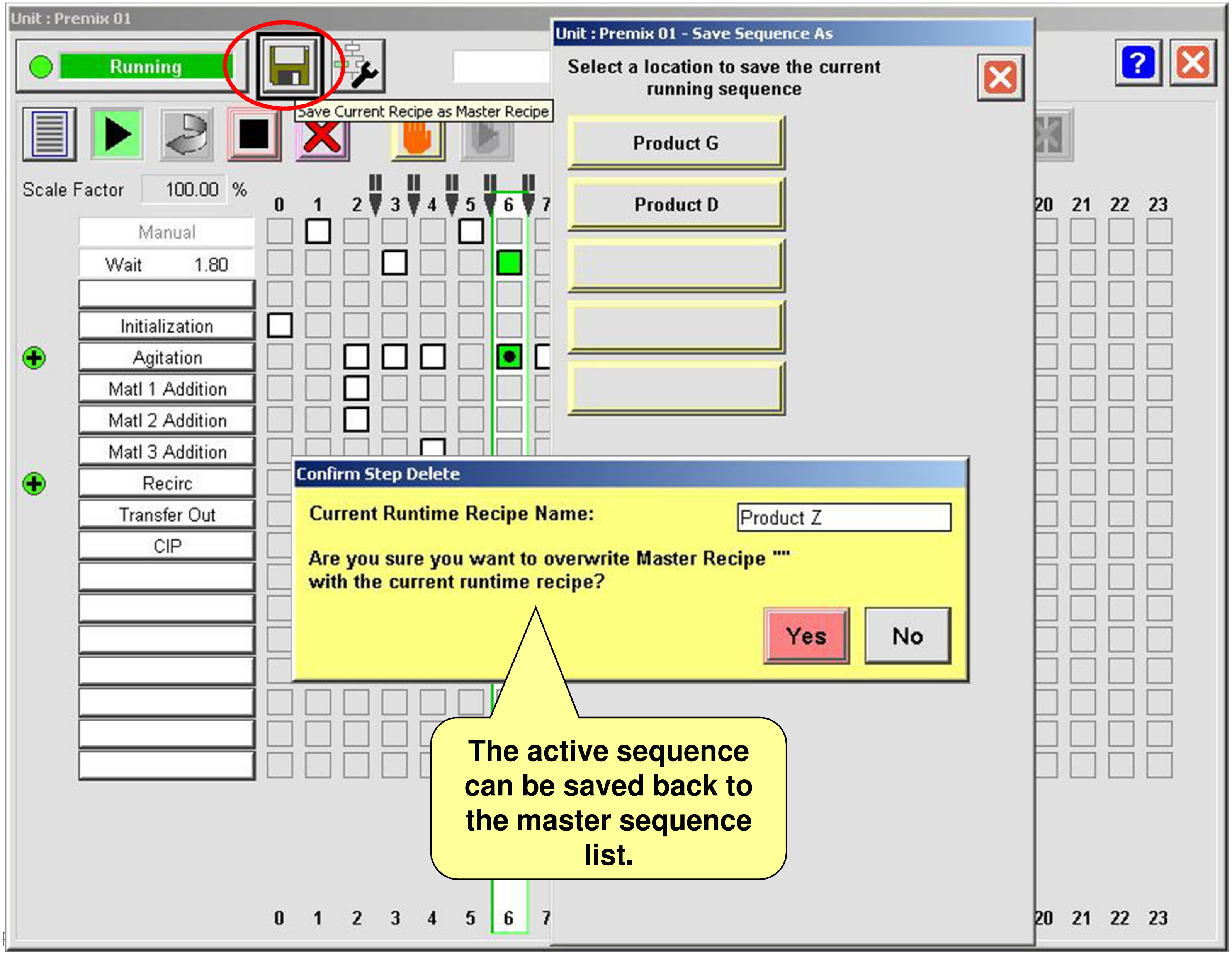
Parameters that can be configured for this phase instance.

Green highlight indicates all phases configured to execute in this step

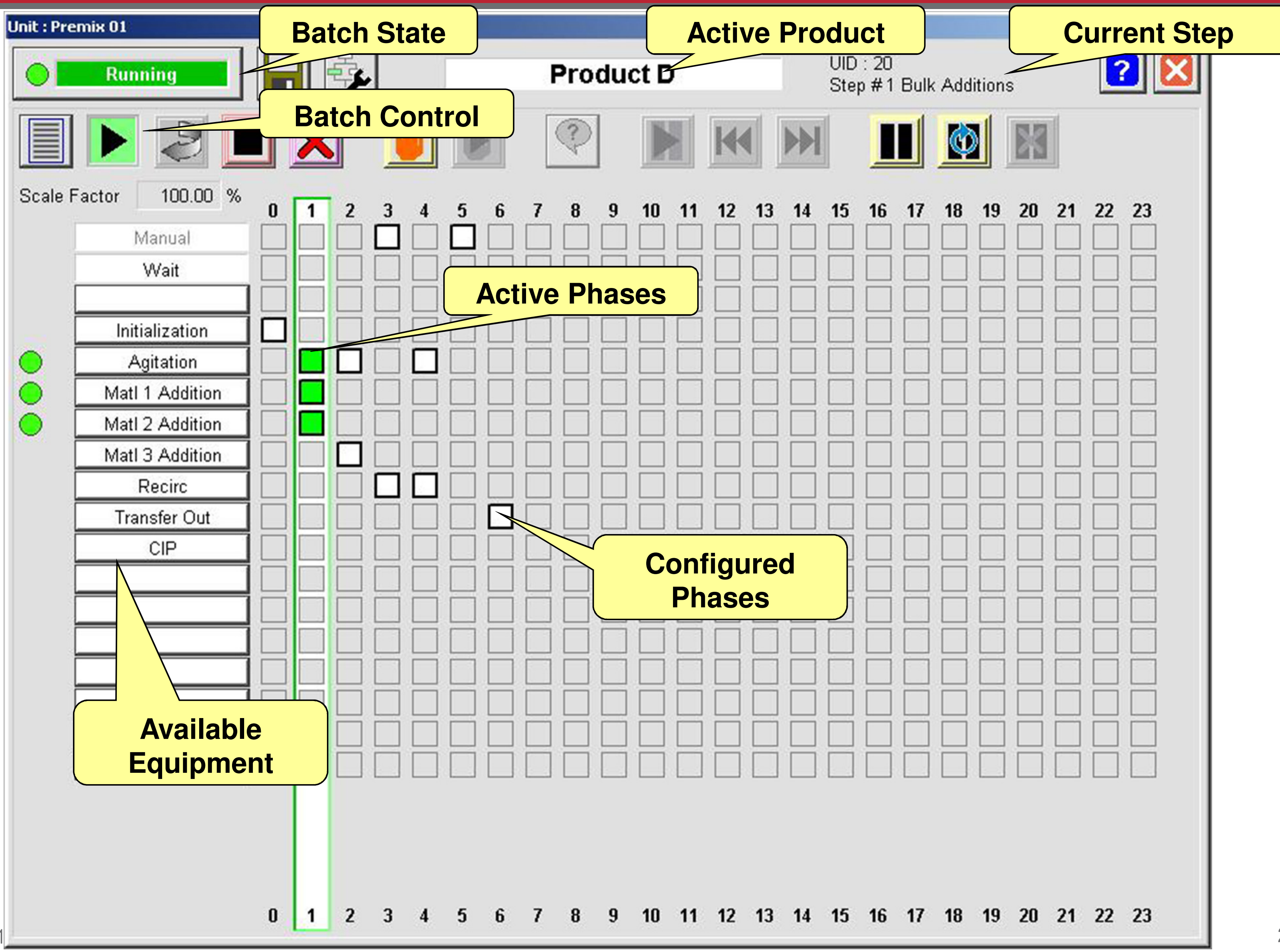
Select Master Sequence



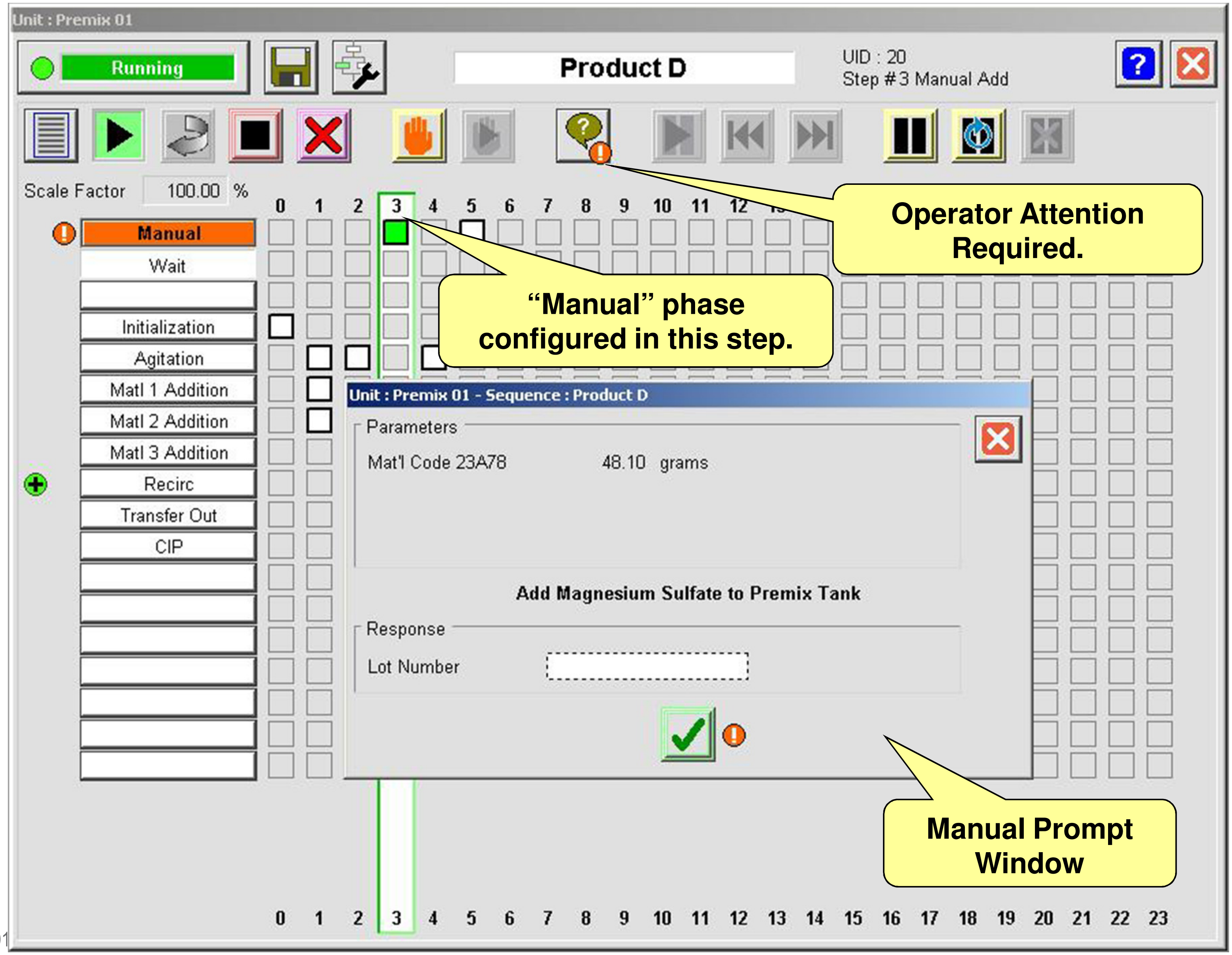
Save Runtime Sequence



Intuitive Runtime Operation



Standard Manual Operator Prompting

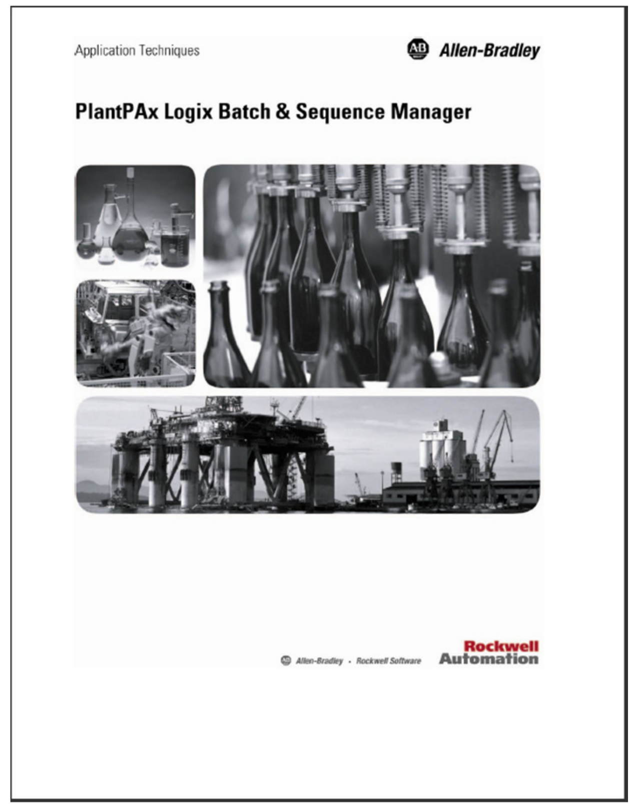


LBSM Application availability and Documentation

- “Logix Batch & Sequence Manager” is available for download through the Rockwell Automation Knowledgebase, Answer ID: 68709
- http://rockwellautomation.custhelp.com/app/answers/detail/a_id/68709

Documentation includes:

1. Installation Guide
2. Configuration Guide
3. Runtime User’s Manual
4. Example project



Comprehensive Batch & Sequencing



- **Software/Server Batch**
  - Integrated solution supports flexible manufacturing, secure recipe management, improved product consistency, & enables regulatory compliance through use of <u>product software & application servers.</u>



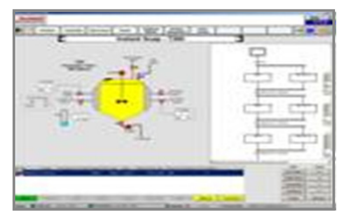
- **Comprehensive Functionality**
  - Enables business system connection, multi-vessel coordination, shared resources, manual operations, & material management



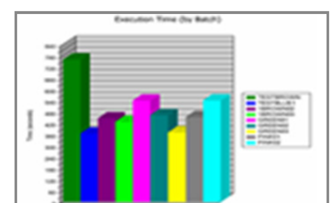
- **Built in Security & Diagnostics**
  - Supports regulatory compliance, secure user environment, & historical change tracking.



- **Data Collection & Reporting**
  - Out of the box data collection & reporting to solve common batch report, track & trace, material usage, and exception reporting needs.



- **Integrated Visualization**
  - Integrated HMI environment enables the user to do more



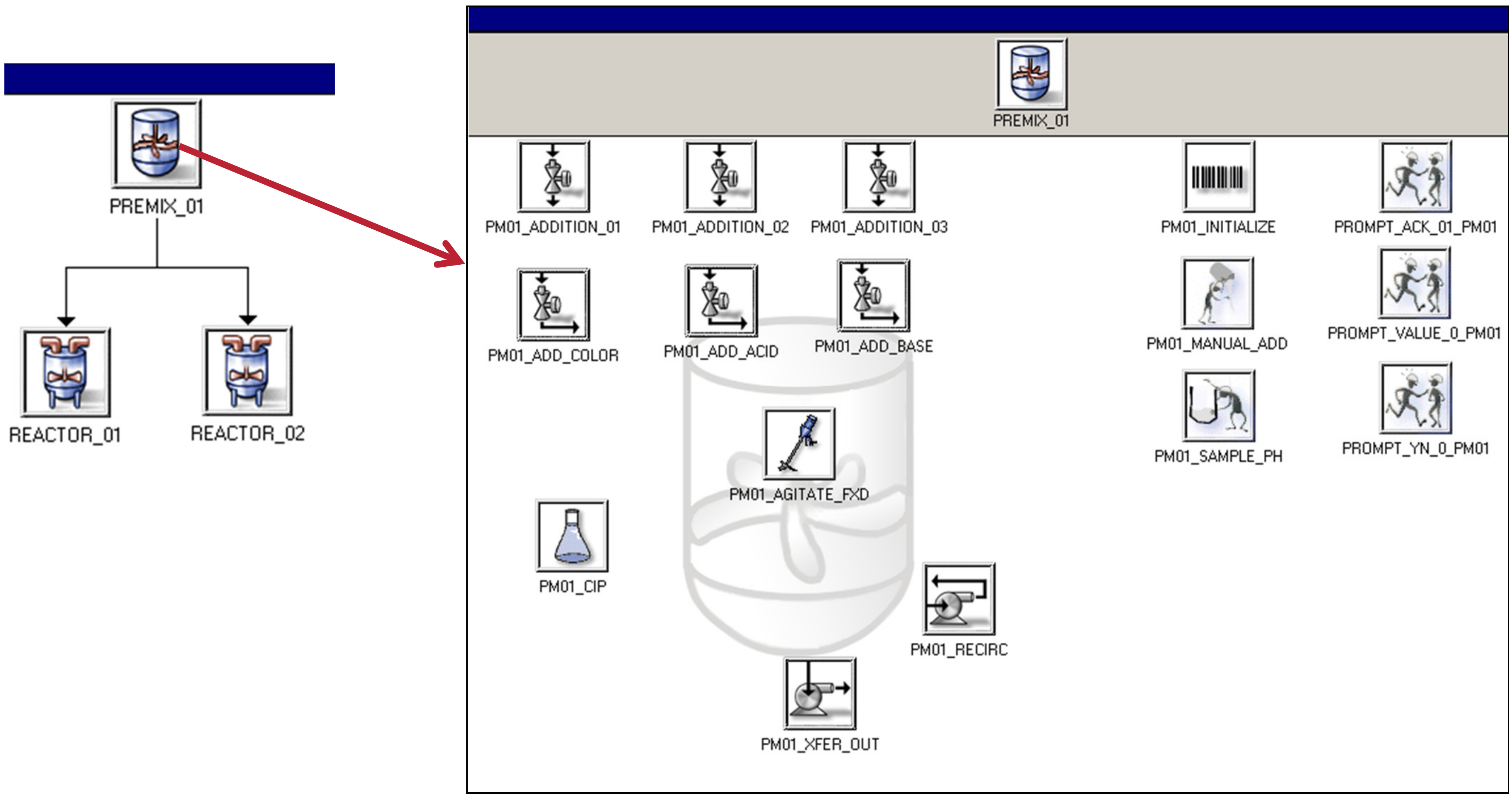
- **Batch Analysis & Optimization**
  - Provides tools to analyze batch cycle time, better understand the process, and correlate process trends

Comprehensive capabilities enable you to meet your demanding requirements

Graphical configuration of Equipment Model

Unit

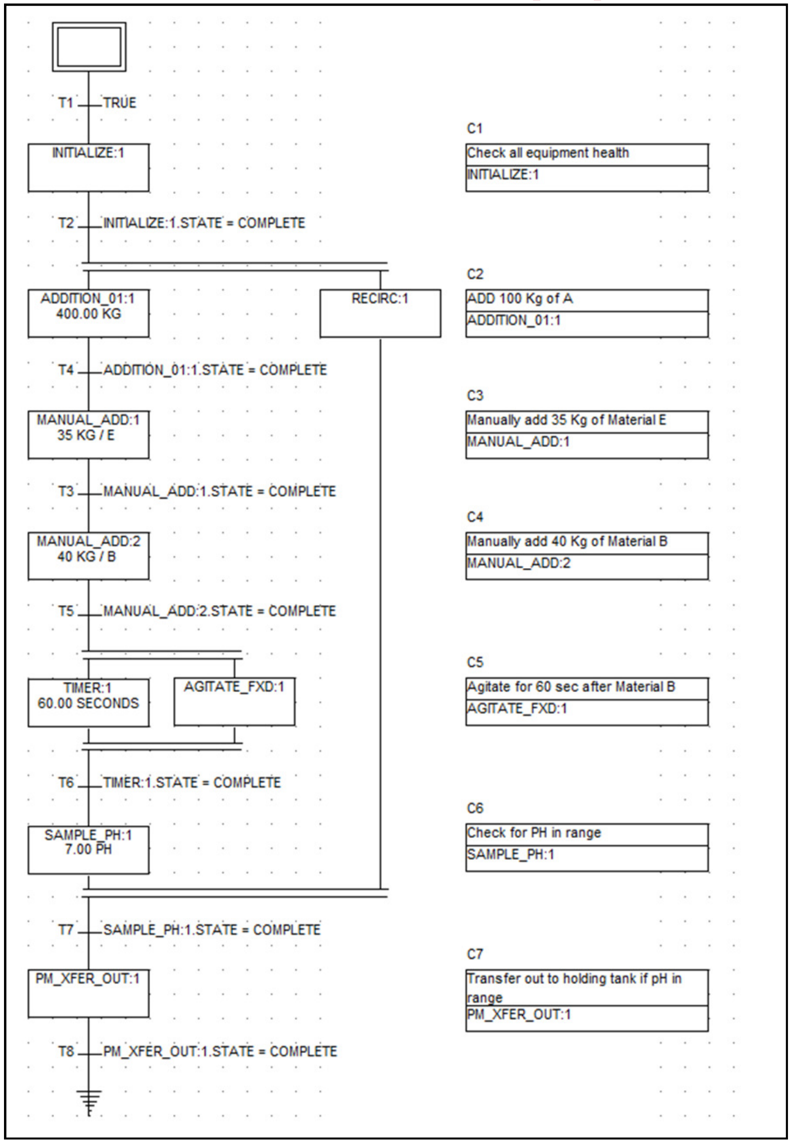
Phases

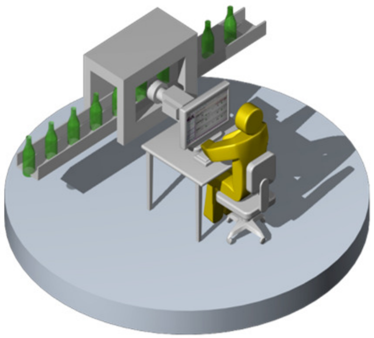


What is the equipment capable of ?

Formulator Aspects (Modularity) Configuration

What to do with the equipment?





Research & Development

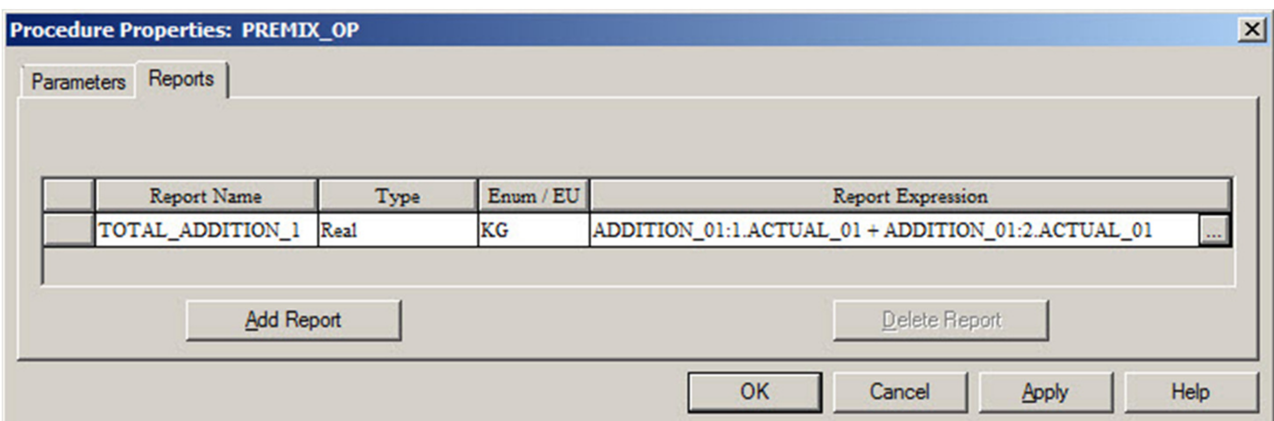
- Product recipes
- Experimental Recipes
- Cleaning (CIP) recipes
- Material Qualification recipes
- Equipment setup procedures
- Dispensing procedures
- Etc.

Formulator aspects (Intelligent recipe features)

– Recipe author's can write parameter, transition, & binding expressions to create “intelligent” recipes that reference unit tags, attributes, input/output parameters.

– Options to define report parameters at all levels of the recipe including phase, operation, unit procedure, and procedure.

– Phase report parameters give you the ability to accumulate values uploaded by phase logic.



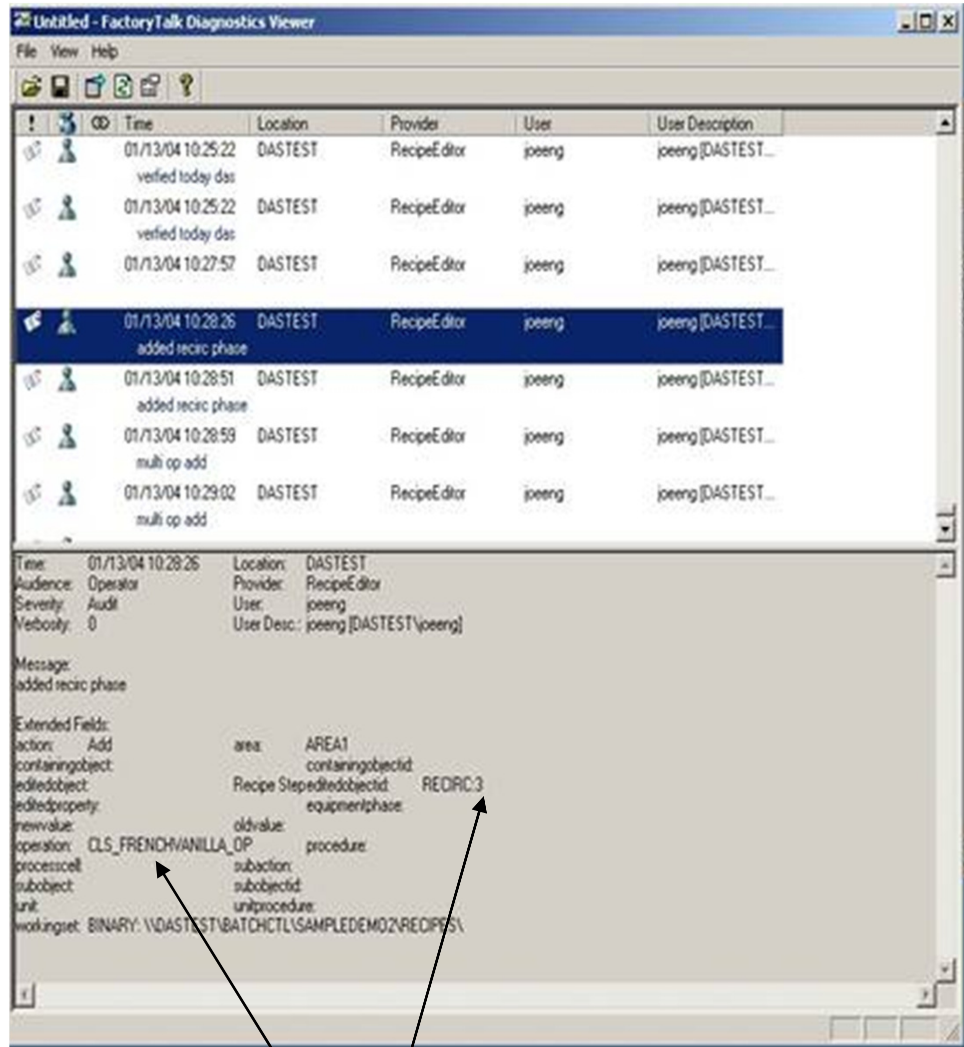
Quality Aspect (Configuration Auditing)

Audits on Equipment and Recipe Editor

Types of Audits Messages

- Security Events
  - Operator tried to Log On at 1:13 pm on January 2, 2009
- Configuration Change Events
  - Report Parameter Added to MIXER_22
- Explanation Events
  - Why a change was made
  - i.e. Set of changes to implement new mixing line.

Audits enabled by Factory Talk Diagnostics



Added a "circulation" phase to the "French Vanilla" recipe.

Operations aspects (Batch Security)

Application security

- User authentication at Logon

Command Authorization security

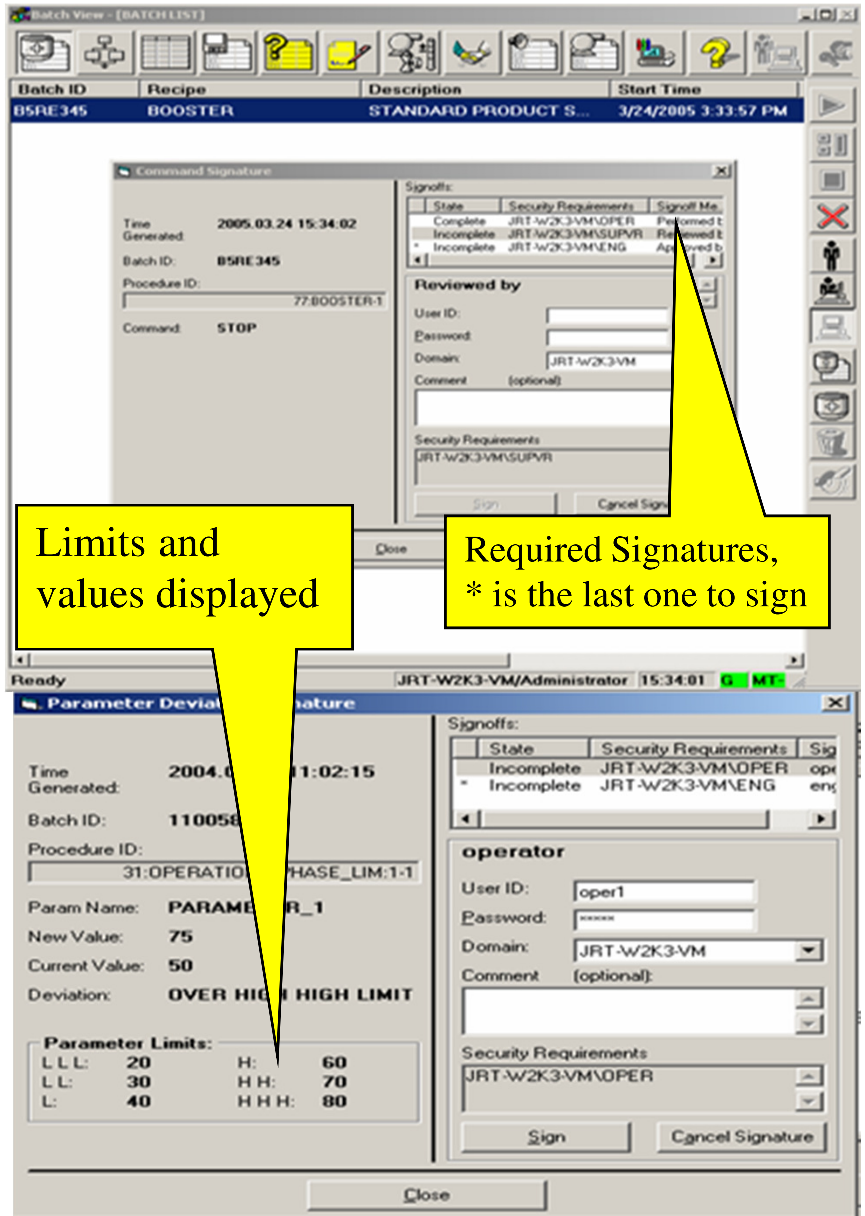
- Full access control to operations
- Ensures that personnel are prompted for signatures when commands are executed.

Parameter and Report deviation authorization

- Manual and Automatic Phases
- Three Levels of limit values can be secured

Electronic Signatures

- Up to three signatures for authorization
- Logs intent of each signature
- Full names logged in event journal
- Available in Batch View and active X’s

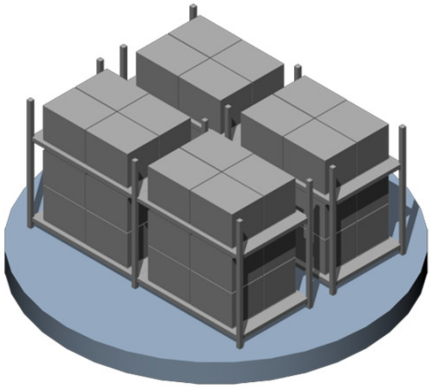


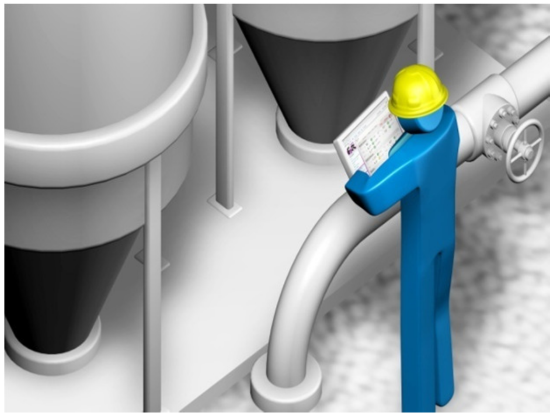
Batch Material Manager

- **Provides an active material management / inventory system**
  - Defines storage locations, containers, and materials
  - Records critical data about material and equipment usage
  - Provides for lot tracking & material genealogy

- **Enables material based phase definitions in batch execution**
  - Enables just-In-time material & equipment selection to provide flexible batch manufacturing & real-time production scheduling

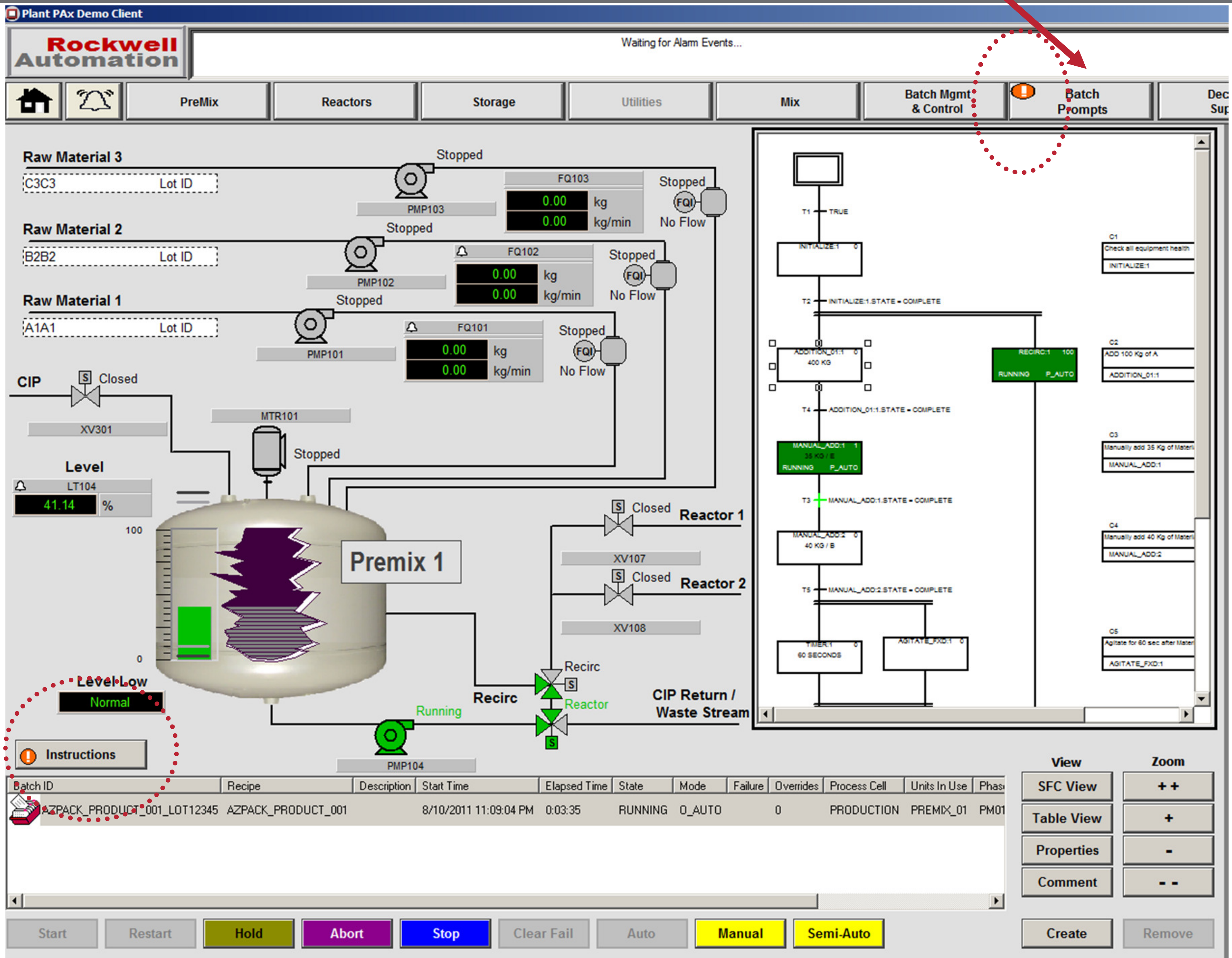




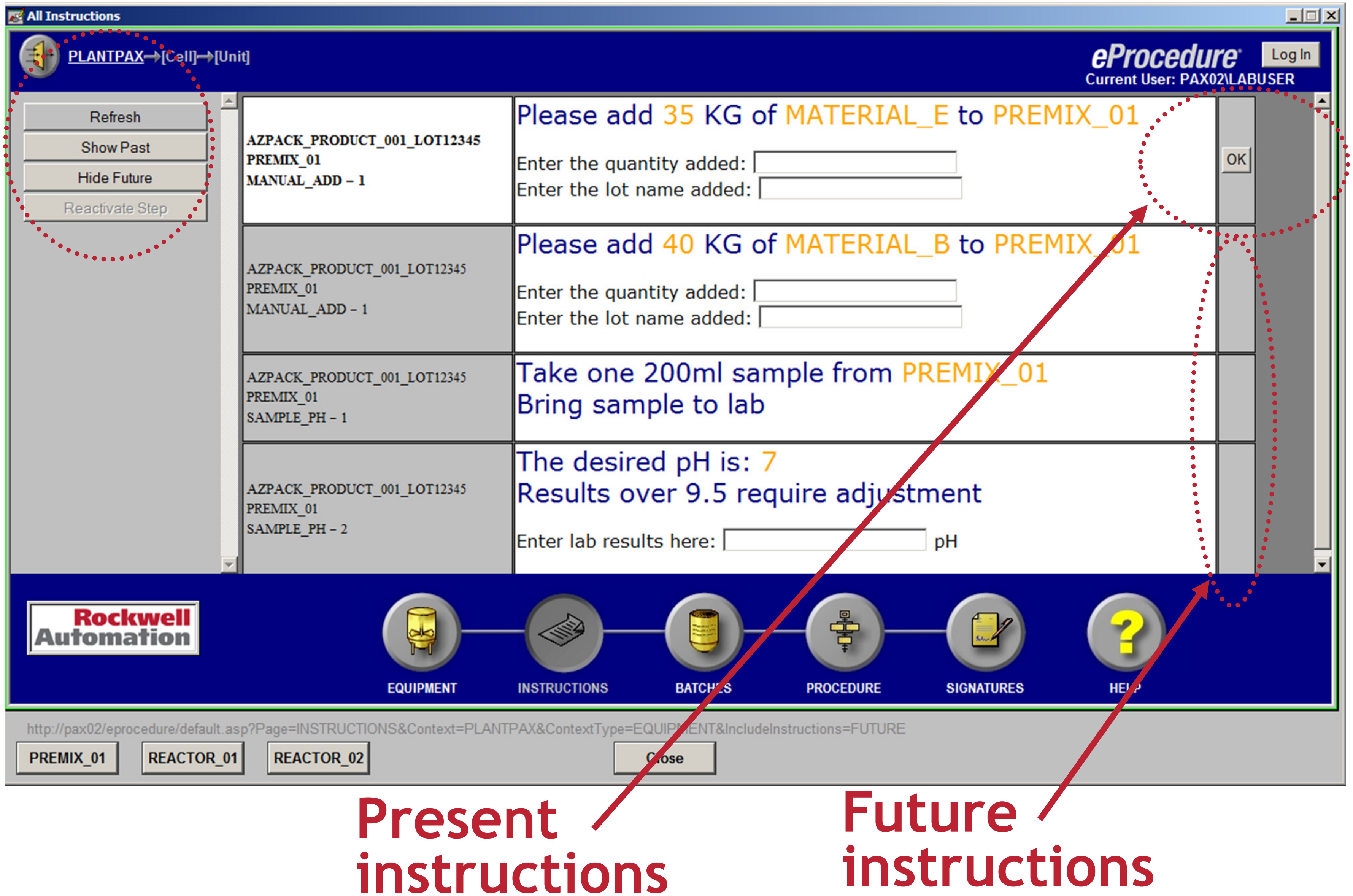


Used to solve material management requirements

Operator Aspects (Operator attention required)



Operator Aspects (Present / Future instructions)



Electronic work instructions

- **Provides automated operator instructions for manual processes**
  - Automates the process without the need to automate the equipment
  - Provides secure and reliable instructions to your operators using web technology
  - Leverage manual SOP's, documents, video, and/or pictures within instructions
- **Integrates manual instructions into automatic batch recipe execution**
  - Provides manual prompts, data acquisition, & SOP's during running sequence.
  - Connect to bar code scanner, databases, controllers within instructions
  - Integrates directly into HMI applications
  - Comprehensive Electronic Signatures



Typical procedures that can be automated

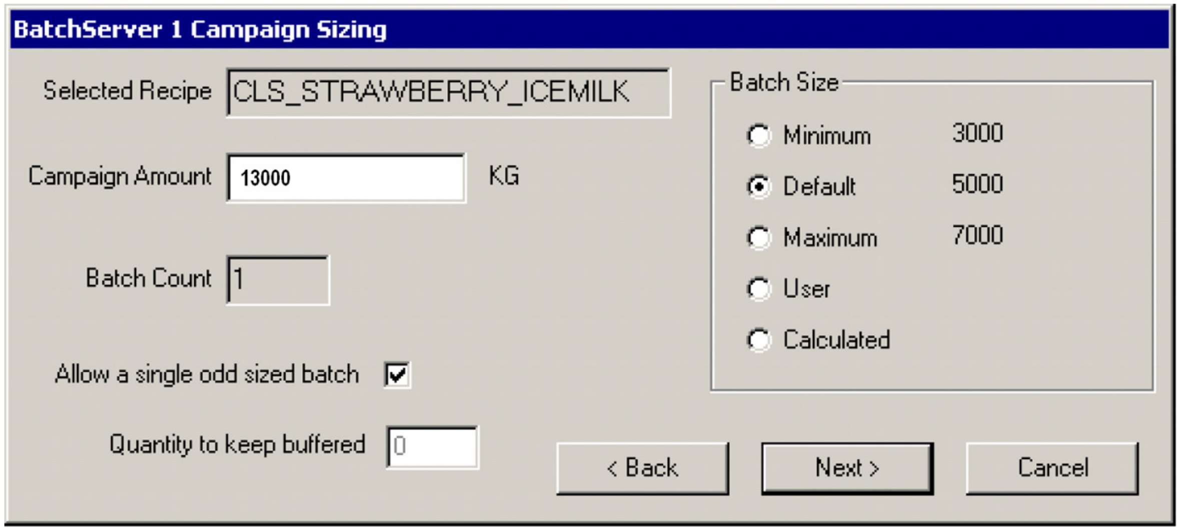
- Manual batch execution and prompts
- Complex standard operating procedures
- Portable hand held applications
- Product changeover and packaging line changes
- Equipment startup and shutdown sequences
- Abnormal condition handling
- Cleaning and maintenance procedures

Use to solve manual SOP requirements

Logistics and Scheduling Aspects (Batch campaign)

Batch Campaign features

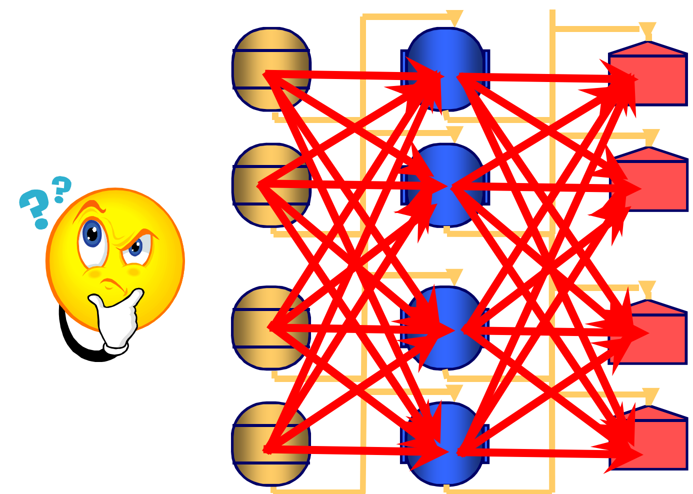
- ❑ **Flexible batch/campaign creation**
- ❑ Add individual batches – you can specify the size of each batch in the campaign.
- ❑ Create campaigns with multiple batches – you can automatically generate the campaign of batches using the quantity/size or a value in between that is applied to all batches in the campaign.



For example, A 13,000 liter campaign size is created with a batch size of 5,000 liters. With **Allow Single Odd-Sized Batch** selected, there will be two batches at 5,000 liters and a single (third) batch created with a batch size of 3,000 liters, thus fulfilling the campaign size specified (2*5,000) + 3,000 = 13,000 liters.

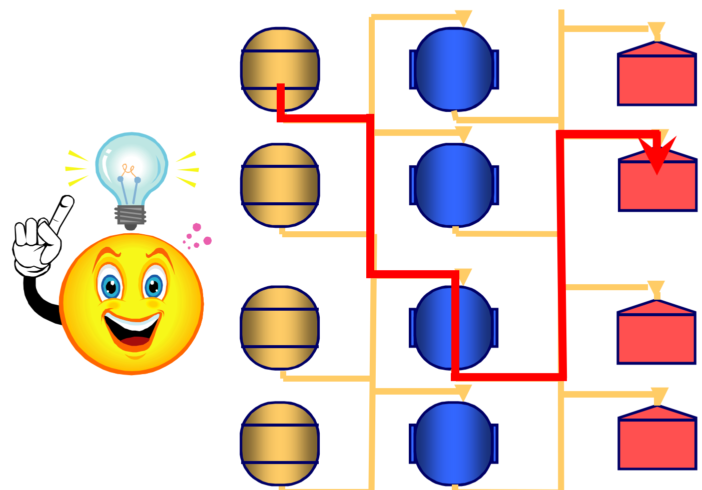
Smart Binding (Equipment auto selected)

- **The enabling technology to build equipment (unit) binding requirements and preferences into procedures.**



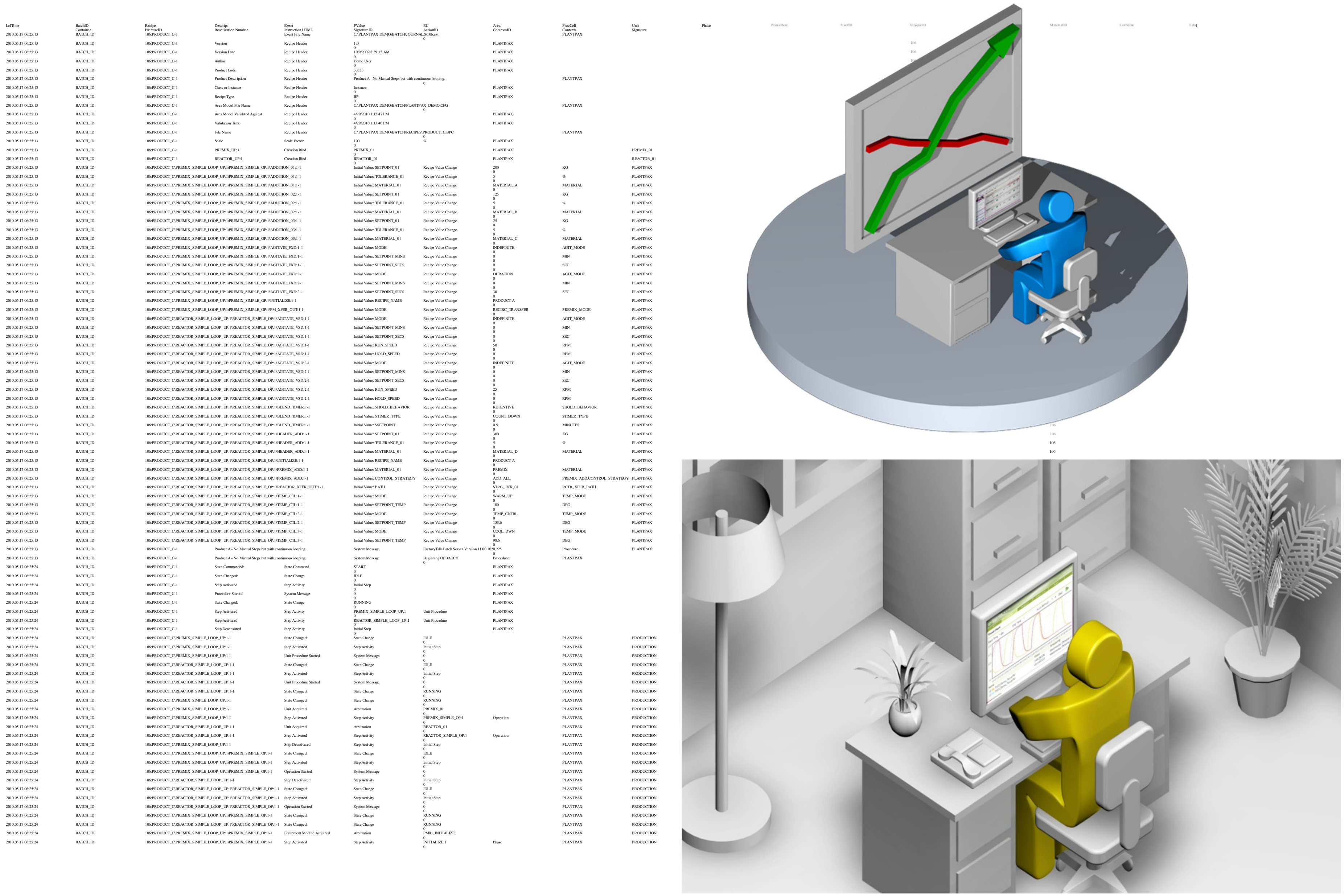
- **Decisions can be based on:**
  - Preference
  - Requirement

- **Use “Smart Binding” to address:**
  - Cost Concerns (use the “warmest” reactor)
  - Clean-in-place Requirements (“peanut-free” product)
  - Out-of-Service Status (scheduled maintenance)
  - Unit/Recipe Compatibility (Glass Lined Reactors)
  - Avoid using Unit with unneeded functionality (recipe doesn’t need agitator)



Use to optimize the production process

Batch execution and process data is generated and stored



Standard Reports Available



Quality



Planning and Logistics



Plant Management

- **010 – Batch Listing -** List of batches that meet a user's search criteria
- **020 – Batch Summary -** Batch specific summary information on batch data like set point vs. actual
- **030 – Batch Detail -** Batch specific detailed information on batch data (step times, parameters, reports), abnormal
  …. state changes, batch failures, FactoryTalk alarms & events, set point vs. actual, and out of
  …… tolerance values.
- **040 – Material Usage -** Material specific consumption information including: batch that consume it, quantity & lot consumed, total consumption over period of search.
- **050 – Forward Tracking -** Find all batches that consumed a material lot or used a piece of equipment.
- **060 – Backward Tracing -** Trace all ingredients consumed and equipment used by a specific batch.
- **070 – Batch Execution -** Review a specific batch's step execution times in a bar chart format.
- **080 – Duration Comparison -** Compare the durations of multiple batches in a bar chart format.
- **090 – Batch Exceptions -** Review all batches with exceptions. Includes abnormal state changes, FactoryTalk alarms & events, batch failures, out of tolerance values

PlantPAx Tools & Apps

– PlantPAx Tools & Apps are now on the RA knowledgebase!
  - http://www.rockwellautomation.com/knowledgebase/

– PlantPAx Table of Contents (TOC) - Answer ID 62366
  - http://rockwellautomation.custhelp.com/cgi-bin/rockwellautomation.cfg/php/enduser/std_adp.php?p_faqid=62366



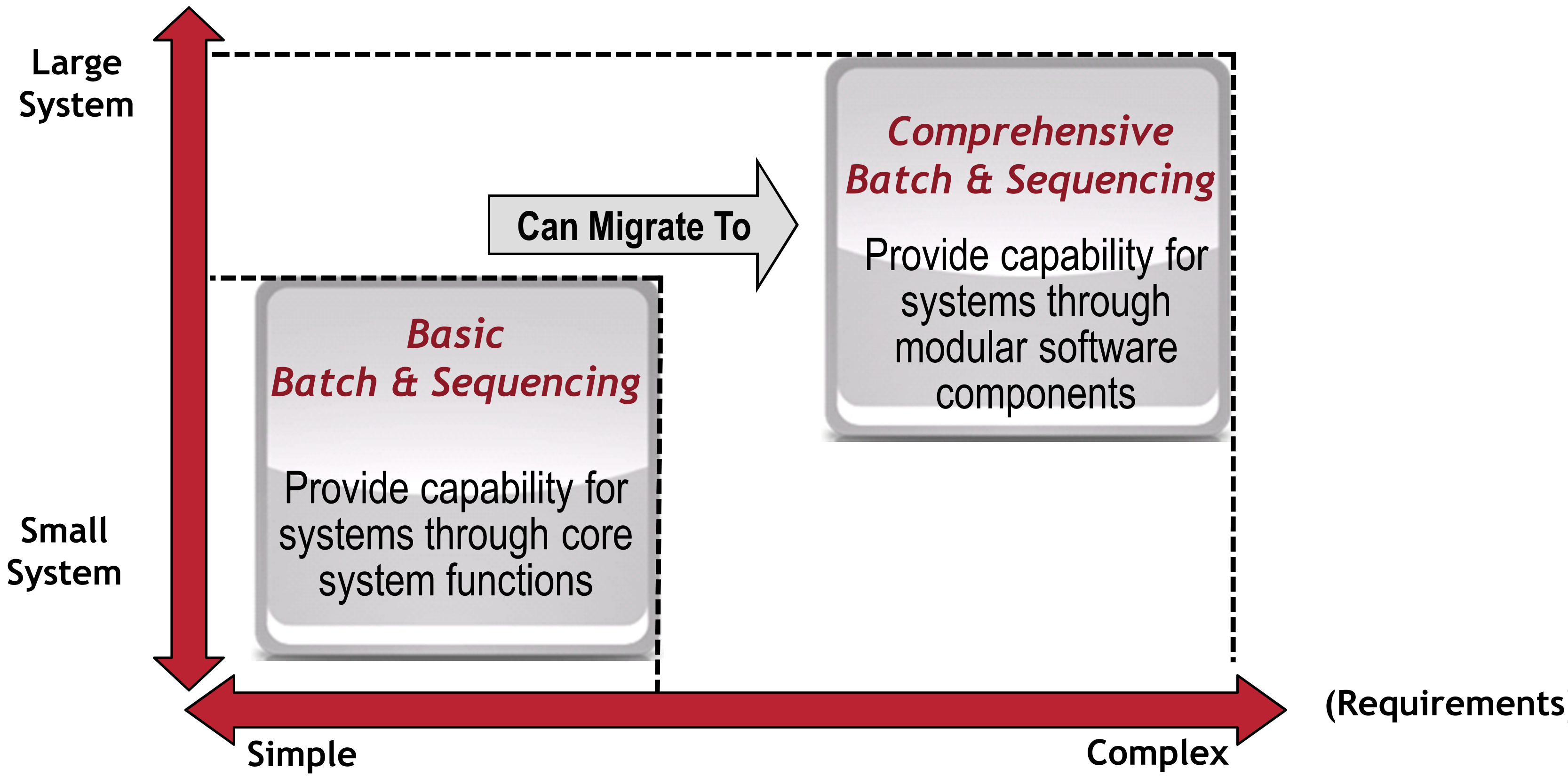
Agenda

- Batch and Sequencing processes
- Batch and sequencing S88 design basis
- Batch and Sequencing Solutions
- Batch and Sequencing scalability
- Scalable solution example
- Selection Considerations
- Summary

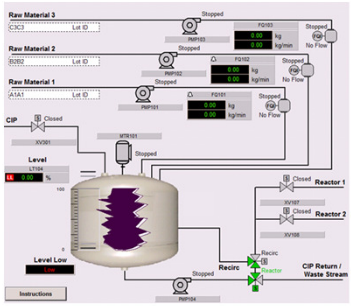
Scalable Batch and Sequencing

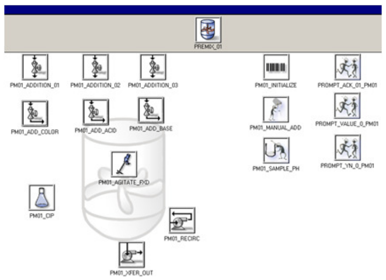


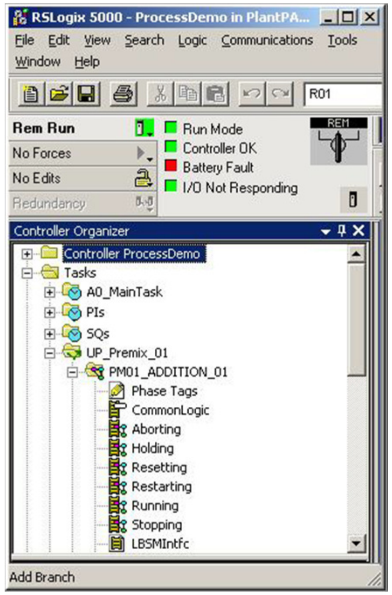
- **Scalable Batch & Sequencing Solution**
  - Leverage Logix PhaseManager technology.
  - Use LBSM to sequence single Unit simple operations
  - Use FTBatch to coordinate multi unit recipe procedures and complex recipes

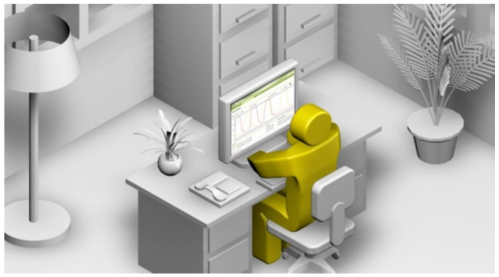


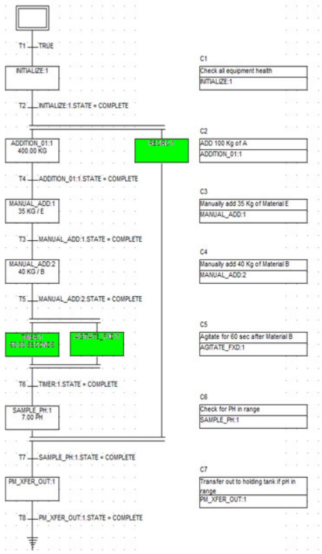
Equipment Phase Modularity











Define Equipment Model

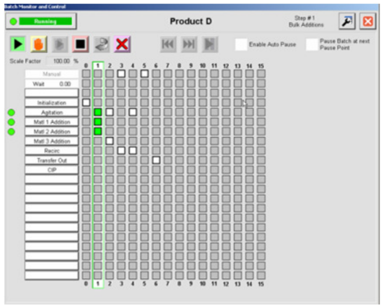
Create Equipment Phases

Configure FTBatch Procedures

Reusable

Configure LBSM Operations

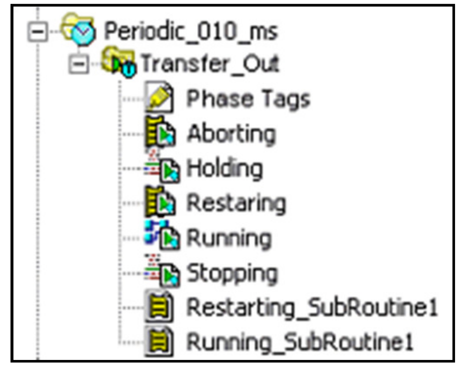




Phase Manager

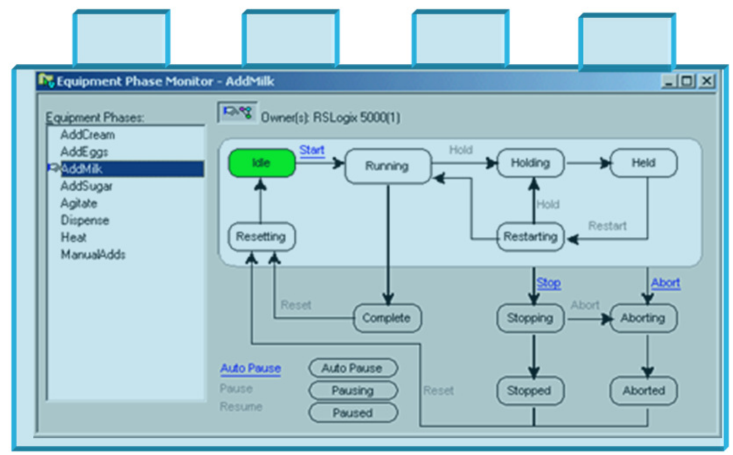
- PhaseManager embeds standardized (Equipment) Phase State Model and management in the Logix controller
  - Provides a **modular framework** for executing Phases in a controller
  - Phase control executed as state machine model, using Phase State Routines (Running, Stopping, etc.)
  - Manages transitions between these standard, allowable States
    Useful for
    - Batch Control **(simple to complex)**
    - Machine Control
    - Other places where simple operations should be standardized

- Phase Monitor provides a monitoring and troubleshooting view of individual phases



Application Code

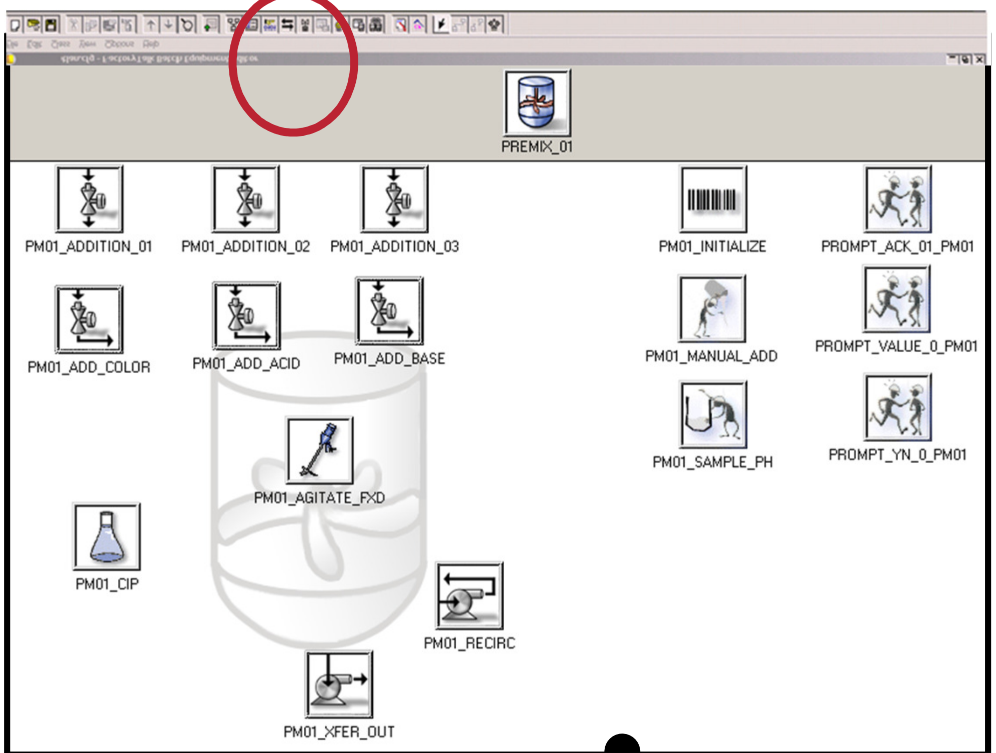
Standard Phase Interface



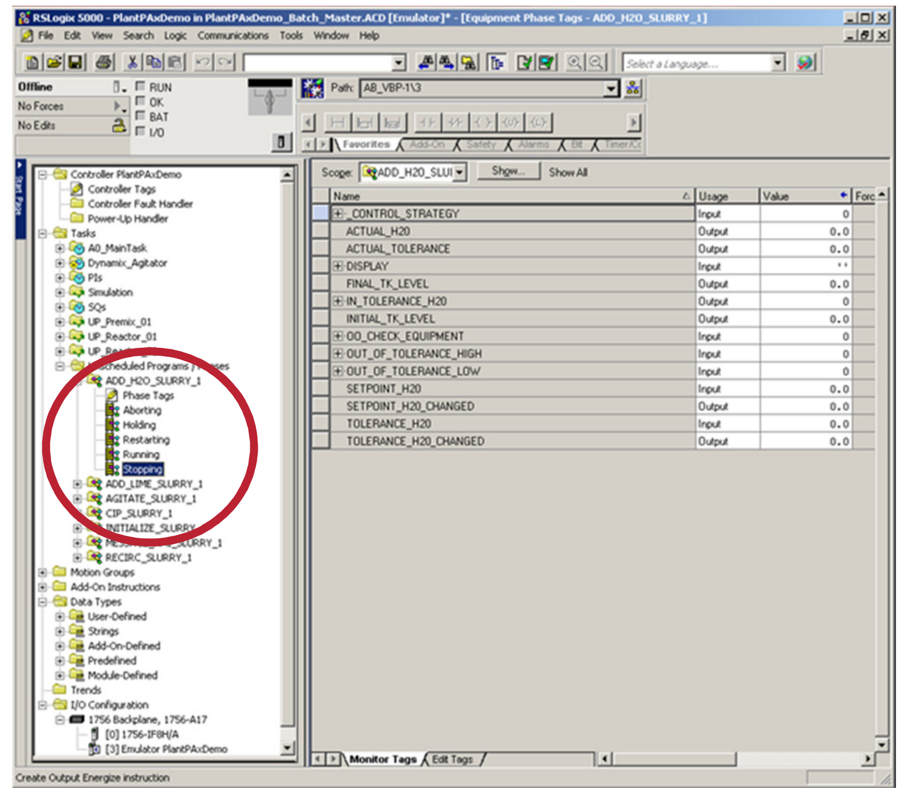
Equipment Phases, built with PhaseManager, Become the Building Blocks

Phase Manager Synchronization

Equipment Model definition

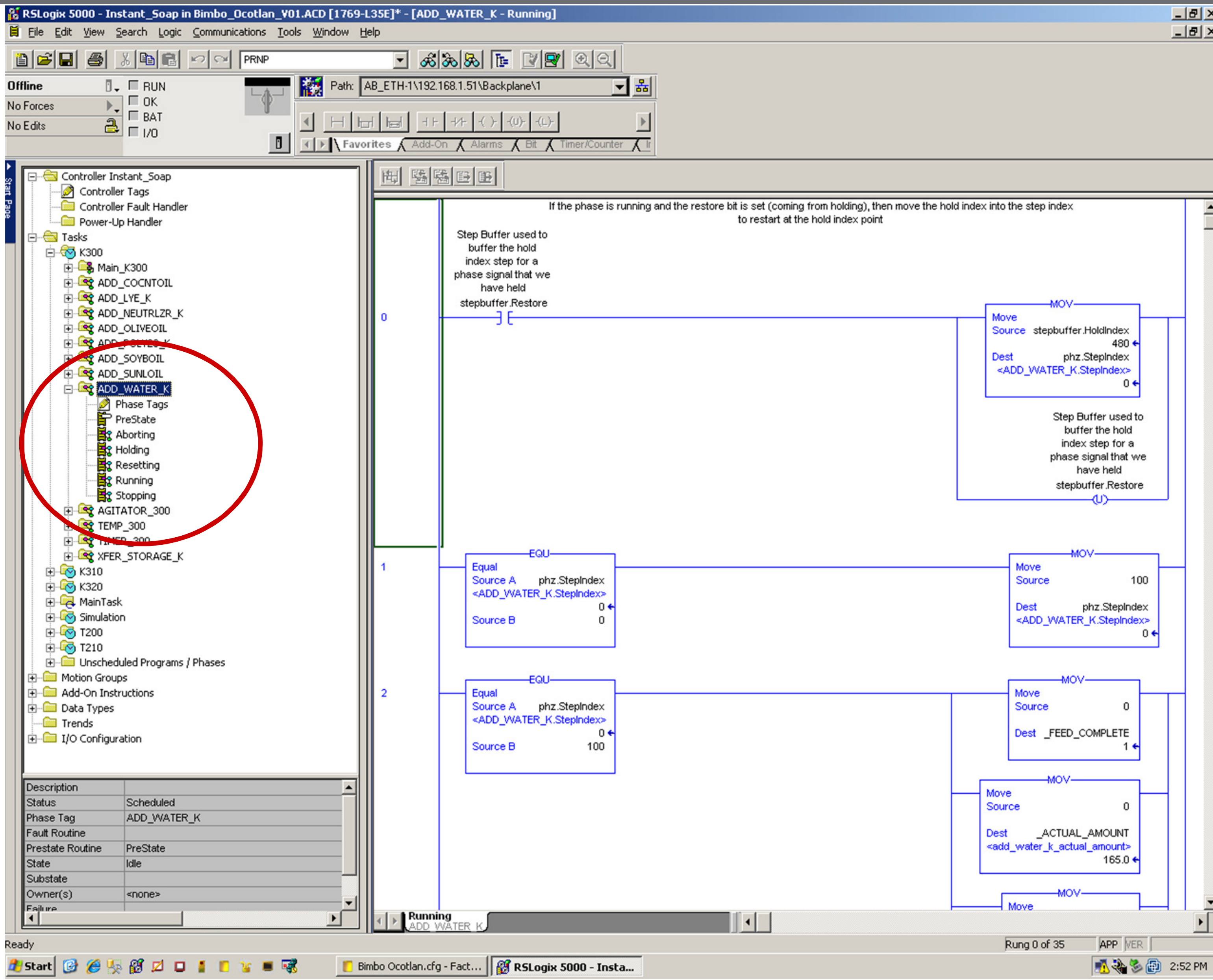


Controller code



Phase Manager Synchronization

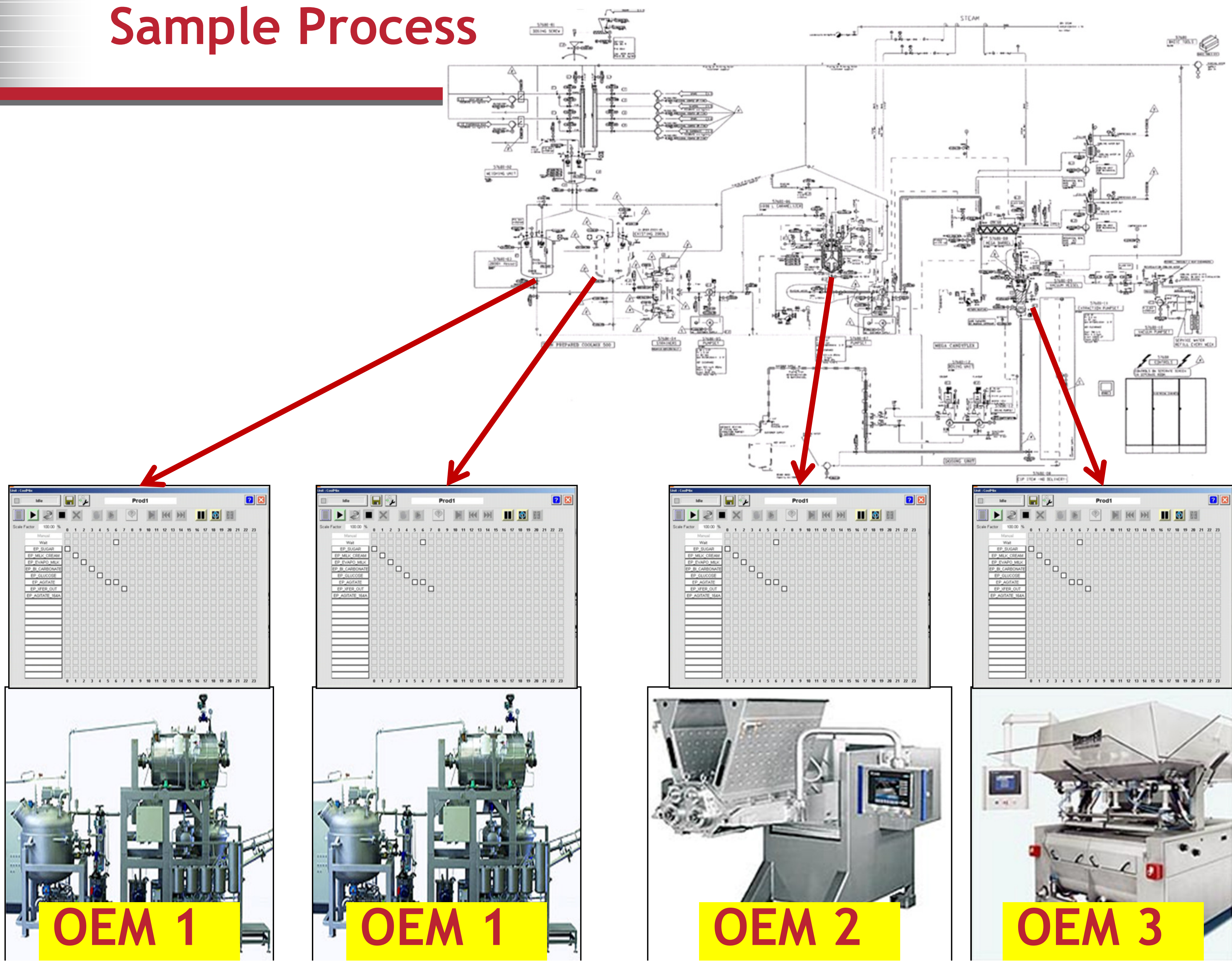
Synchronize with Controller



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Sample Process



OEM Equipment

<u>Benefit:</u>

All 4 OEM solutions utilize the same process control foundation, the code structure does not have to change. This allows the OEM to maintain a single process control solution independent of the sequencing engine used, thus *reducing engineering costs and delivery time*.

<u>Benefit:</u>

The OEM equipment can be delivered as a fully functioning skid that can seamlessly integrate into the end users overall control system. Complete factory acceptance tests using LBSM or FTBatch sequence managers. But at the site, you can perform direct integration into the higher level batch and sequence management software such as FactoryTalk Batch to *reduce startup time and validation effort.*

<u>Benefit:</u>

If the OEM skid uses PhaseManager, it can be integrated directly into FactoryTalk Batch at a higher level through synchronization. If the OEM skid uses Logix Batch & Sequence Manager, it can execute operation level sequence that is initiated from this higher level batch software. Both options offer *reduce startup time and validation effort.*

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Fundamental differences



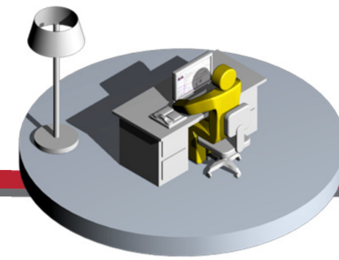
PC Based Solution (FTBatch):

- Sequences are store and directed using a PC.
- Multiple forms of graphical user interfaces exist to interact with operators(web browser, active X, FTBatch view) other GUIs are used by formulators and engineering.

Controller Based Solution (LBSM and SILC):

- Sequences are executed and stored using a Controller (CLX).
- Human Machine interphase (Vie SE or ME) is used to interact with operators, formulators and engineering.

Selection considerations



Cost:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• Free sequencing engine HMI and CLX Application code.	• Requires View SE or ME • Requires a Controller	Includes: • Sequencer engine • Operator electronic work instructions • Material management • Batch campaigning • Formulation management • Electronic journal • Web based reporting • No controller required • No HMI required (batch view)	• List Price (see table below)

List Price:

Units	1	3	10	30	60
US$	3k	8k	24k	47k	68k

Equipment requirements:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• Does not require a windows sever operating system	• Requires a CLX • Requires View SE or ME	• User interface Batch View, Active X, web browser or View SE, ME. • Does not require a CLX • Multi controller interface and coordination	• Requires a Server OS to run Batch Server • Requires an OS to run Clients

Selection considerations



Robustness:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• Recipe will continue to run in the controller without HMI or Network.	• Recipe will continue to run in the controller without HMI or Network. No operation view if loss of network. • Loss of power will cause loss of current sequence state	• Components detect loss of network or server and bring recipe and phases to held safe state. • Upon system restore the recipes reconstruct and recipes continue were they left off after operator restart.	• Requires the PC and the network in order to continue sequence • No built in redundancy, rely on third party

Reporting:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• (Reporting under development)	• Custom reporting required • Cost of implementation • Only "Real" values type data is captured no strings nor enumerations	• Comprehensive data collection performed by Batch server • Ability to move data to multiple data bases • Free existent predefined reports • Interaction with FTHistorian provide the ability to correlate Batches with batch historical data such as trends	• Requires an operating system

Selection considerations



Equipment definition and specification:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• All equipment model configuration is performed via HMI • Ability to add equipment phases to definition without affecting running recipes • Simple to understand and deploy • Controller memory usage tool available • Ability to add or remove Units, Phases, parameters and report values on the go • Only requires HMI and CLX know how to maintain	• Parameters of type Real and Boolean and report values of type real limited to 4 of each • No strings nor enumerations parameters nor report values • All equipment definition require the same controller memory overhead to be reserved whether it is used or not • Maximum of 32 independent Units • Maximum of 32 Phases per unit • Consumes CLX processor memory estimating tool available	• Non limited number of parameters and report values • Each equipment definition can be different for units, phases, parameters and reports • Types integer, real, strings, enumerations • Unit attributes allows equipment to be automatically selected based on equipment conditions • Phases have the ability to acquire shared resources • Equipment allocation and arbitration is performed by Batch Server not in the controller • CLX not required to run • Equipment phase logic can be distributed among multiple controllers or varying types • Unit and Phase class definition	• Addition of new equipment require stopping and restarting batch server service, no online equipment definition changes allowed.

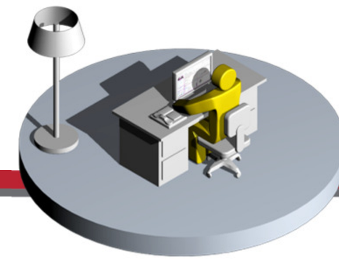
Selection considerations



Recipe definition and usability:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
• Very intuitive user interface for operator and formulators • Ability to modify existent running recipe on the go • Ability to save running recipe as master recipe. • Simple to step forward or backwards to predefined pausing points • All recipe definition is performed via HMI • All recipes definition reside in the CLX controller	• Single unit recipes • No class based recipes, each one needs to be maintained individually • One operation per recipe • No recipe structure reusability • Maximum of 32 steps per recipe • Maximum of 32 recipes • All recipes reserve the same amount of controller memory regardless of number of steps or recipes per unit • Recipe step transitions are based on phase completion • No looping or branching in recipe always performs the same steps of a sequence • Risk of losing recipe intellectual property by exposing CLX code to anyone working in the controller	• Multiple unit recipe coordination • Reusable recipes operations and unit procedures that can be called by other recipes • Ease of creating, saving and replicating recipes • Class based recipes allow one recipe to run in multiple units at the same time, simplifying recipe management and control • Number of recipes virtually unlimited, recipes may contain many steps • Recipes do not reside in the controller and do not consume controller memory • Recipes are transportable (copy paste) • Recipes changes are audited • Phase parameters and reports can be calculations that reference other parameters and report values, unit tags, etc. • Recipe step transitions can be configure to be the result of calculate values, unit conditions, recipe conditions, reported values, parameters, equipment states, etc, or simply phase complete • Looping and branching ok	• Changes made to running recipe can not be store as the master recipe. • Steps can not be added nor removed from running control recipes.

Selection considerations



Material Management:

Controller Based (LBSM)		PC Based (FTBatch)	
(+)	(-)	(+)	(-)
•	• Not in scope	• Ability to determine location of sources of material required by recipes. • Ability to manage raw material, intermediate and finished product inventory • Ability to define material types and properties, to be used by recipe in order to dynamically adjust parameters based on material properties. • Ability to define storage container usage priorities for supply as well as consume • Ability to switch material storage location based on incomplete or insufficient material in containers.	• Required Data base to store material information

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Summary

PlantPAx offers a scalable continuum of solutions to cover the wide range of system sizes (small to large) and range of user requirements (simple to complex). Basic capabilities allow you to start small and expand if needed. Comprehensive capabilities enable you to meet your demanding requirements.

Phase Manager

Controller based phase infrastructure

- PhaseManager embeds standardized (Equipment) Phase State Model and management in the Logix controller

Basic Batch & Sequencing

Configured Batch & Sequencing LBSM

- Provides configurable batch & sequencing through standard controller and HMI functions

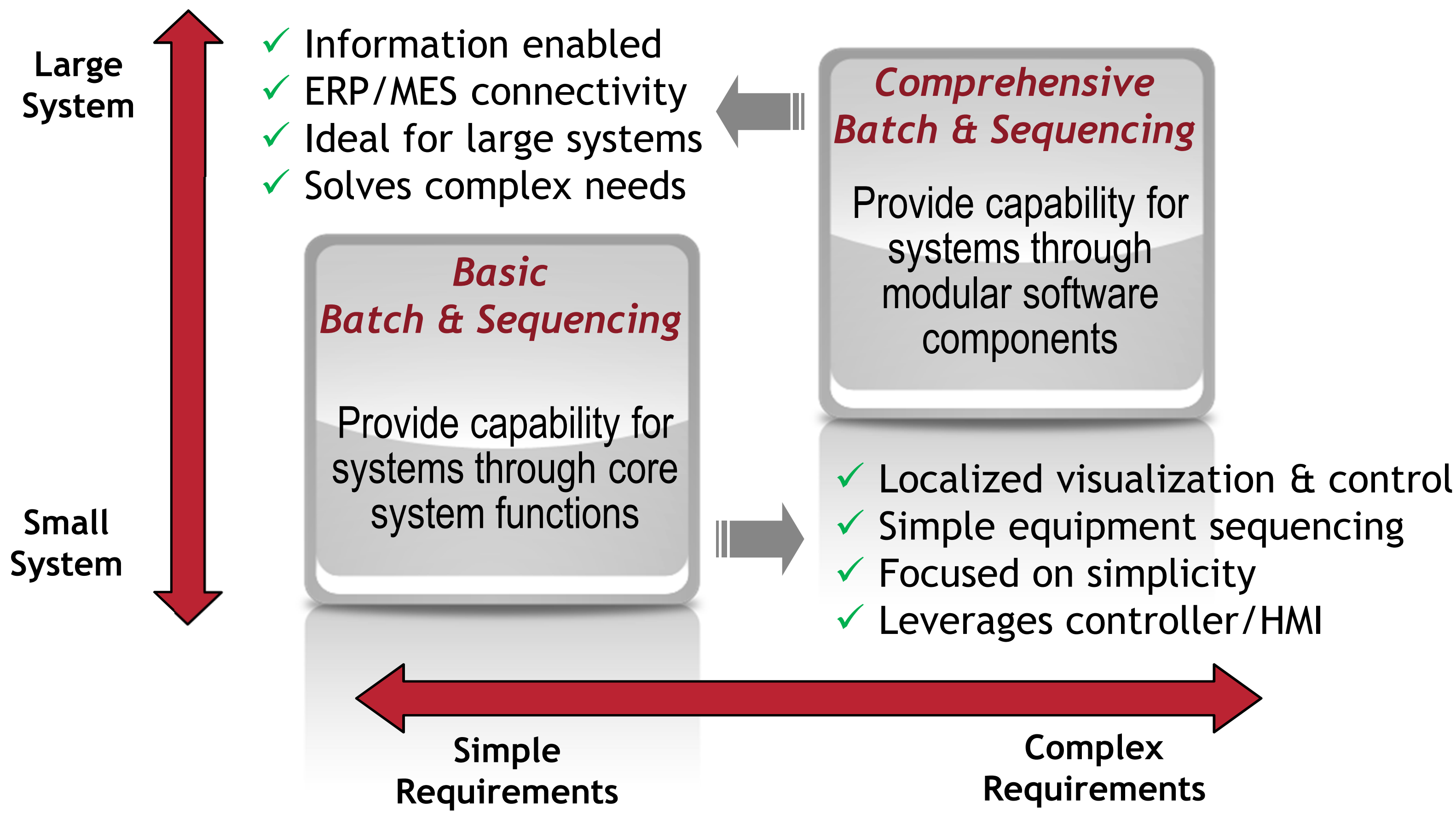
Comprehensive Batch & Sequencing

Application Server Batch & Sequencing FTBatch

- Provides pc-based solution for maximum flexibility for large systems

Batch/Sequence Management & Control

- **Scalable to meet a wide range of batch and sequencing requirements**
- **Improve yield, increase throughput, reduce costs, and improve quality**



Rockwell's response to market demand for scalable solutions

Thank you!

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THINKING PROCESS

Rockwell Automation
Process Solutions User Group (PSUG)
November 14-15, 2011
Chicago, IL – McCormick Place West